WATER WORKS & SEWERAGE

September, 1936 — Editor — Volume 83. No. 9

IN Tulsa OKLAHOMA

Tulsa, an entrancingly beautiful city, so clean that it seems as if it had been built only yesterday, is located in the northeastern section of Oklahoma. A city whose progress has been so rapid that many residents now living and active in business life can remember when Indian teepees were spattered colorfully over the grazing lands on which great skyscrapers have been built towering almost into the fleecy clouds.

Its strategic location as the hub of the mammoth oil and gas fields of the Southwest, has contributed much to Tulsa's rapid progress.

To keep pace with Tulsa's rapid industrial expansion and growth in population, the City Administration has wisely planned an adequate and efficient water department, and placed at its head an experienced commissioner. Sparkling spring water, a supply enough for a city of more than three times its size, is obtained from Lake Spavinaw. The twin reservoirs, Mohawk and Sequoyah Lakes, hold sufficient supply of water to last Tulsa 90 days. The pure Spavinaw water is made doubly pure at the city pump station and filtration plant before it is distributed through the many miles of water mains.

As in many other progressive municipalities Pittsburgh Water Meters are in use in Tulsa.

PITTSBURGH EQUITABLE METER CO.
MERCO NORDSTROM VALVE CO.
MAIN OFFICES PITTSBURGH, PA.

NEW YORK · LOS ANGELES · TULSA · HOUSTON · MEMPHIS · BUFFALO
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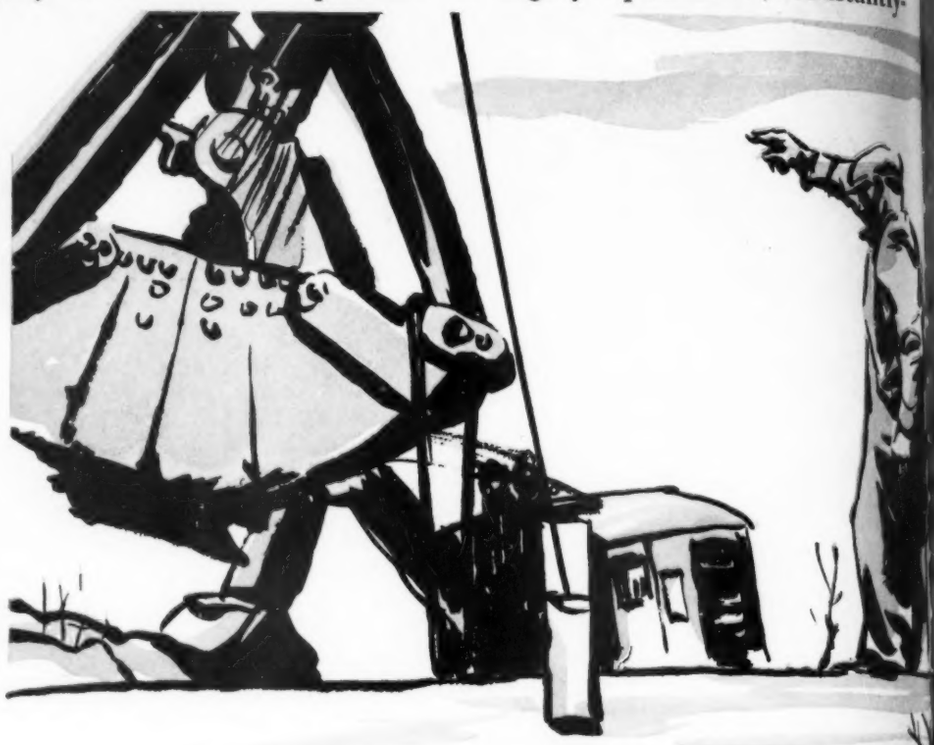
PITTSBURGH WATER METERS

ABC DESIGN · CONSTRUCTION · COLLECTION
TREATMENT · DISTRIBUTION · DISPOSAL ABP

FURTHER back toward nature than any other ferrous material used for underground mains, and among the oldest of such materials, cast iron pipe as made today is the modern product of highly specialized, constantly-progressing techniques. For example, up to a few years ago it was considered commercially impracticable to cast gray iron in a metal mold without chill. Yet that "impossibility" is daily achieved by our centrifugal casting units at Burlington, Birmingham and Bessemer in the manufacture of Super-de Lavaud Pipe.



U.S. cast iron PIPE

Cast iron and alloy cast iron pipe centrifugally or pit cast—for water works, gas, sewerage and drainage service as well as industrial uses involving corrosives.

U. S. PIPE & FOUNDRY CO.
BURLINGTON, NEW JERSEY
Foundries and Sales Offices throughout the U. S.

SUPER-DE LAVAUD CENTRIFUGAL CAST IRON PIPE

U. S. Pit Cast Pipe U. S. Threaded Cast Iron Pipe U. S. Mechanical Joint Pipe
U. S. Ni-Resist Cast Iron Pipe U. S. Flexible Joint Pipe U. S. Cast Iron Culverts
Alloy and Gray Iron Castings U. S. Cast Iron Roof Plates

Perchloron

a standby source of chlorine instantly available

Even if the unexpected happens, the water supply can be safeguarded when you have Perchloron on hand. Such was the case during the floods last Spring when normal facilities in many instances were rendered temporarily useless.

And in routine service also, Perchloron proves its great value. Use it as a convenient, concentrated source of chlorine to sterilize new mains—to sterilize clear wells and filters. For swimming pools, Perchloron offers many definite advantages.

Perchloron has an available chlorine content of more than 70%. Comes in stable, concentrated form, stays full strength. Dissolves immediately in water. It is perfectly uniform—simplifies technical supervision. Packed 12 handy-sized cans to the case—no return containers to bother with.

It is both wise and economical to keep on hand an ample supply of Perchloron. Write for descriptive literature today.

LIQUID CHLORINE OF HIGH PURITY
86 years' experience stand behind the uniform, high quality of Chlorine produced by Pennsylvania Salt Manufacturing Company

EST. 1850 TRADE MARK

PENNSYLVANIA SALT MANUFACTURING COMPANY

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Arrived ★ COLUMBIA LIQUID CHLORINE

★NEW..ULTRA-MODERN PLANT NOW IN PRODUCTION

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Specify COLUMBIA ★

Delivery in single and multiple unit tank cars . . Also in 100 lb. and 150 lb. cylinders.

And · of course · the same top standards of purity, uniformity and SERVICE that have distinguished COLUMBIA products for nearly half a century.

★ SODA ASH
★ CAUSTIC SODA ★
MODIFIED SODAS
★ CALCIUM CHLORIDE ★
AND NOW
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THE COLUMBIA ALKALI CORPORATION

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CAREW TOWER, CINCINNATI • GRANT BLDG., PITTSBURGH • Plant at Barberton, Ohio

CEMENT, which has had a successful pipe service record for over 60 years, has gained a well-earned recognition not only on new pipe but in the reconditioning of mains that have been in service and have had their capacities materially reduced through tuberculation and incrustation.

Serious tuberculation and incrustation in pipe lines resulting in great losses of carrying capacity, can now be overcome by a NEW method which increases the original carrying capacity indefinitely at a moderate cost.

Forty years ago, when T. A. Gillespie Co., originally installed the 48-in. Pequannock steel water supply line of the city of Newark, N. J., its coefficient was 110 (Hazen and Williams). Today, on the five-mile section reconditioned and tested the coefficient is 124. Cleaning plus CEMENT LINING applied by CENTRIFUGAL MACHINE is the answer.

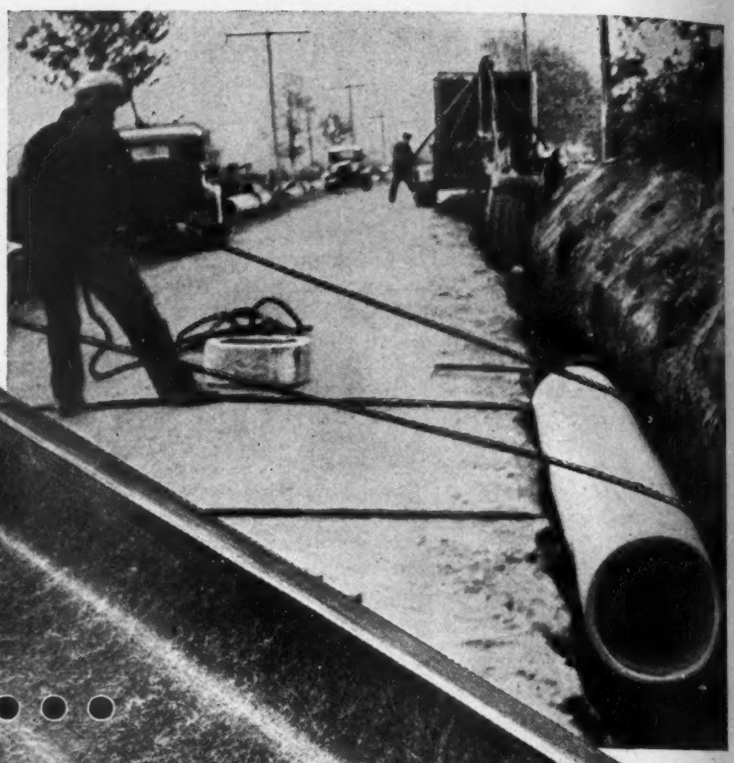
If you are interested in restoring and sustaining the original carrying capacity of old steel or iron pipe, or contemplating new pipe installations, please communicate with us.

The Cement Lining Machine throws the cement against the pipe wall by centrifugal force: the trowels effect a smooth, glazed surface resulting in a permanent maximum carrying capacity.

SAVES ON INSTALLATION . . .

TRANSITE PIPE is light . . . handles economically. And the Simplex Couplings not only provide rapid assembly, but also eliminate caulking . . . meaning that unskilled labor can be used and trenches held to minimum width. Result, a definite, sizable saving on installation.

(RIGHT) 16" Transite handled without mechanical equipment. Simplex Couplings eliminate the necessity for large bell holes. Note the unusually narrow, highly economical trenching.



IN SHORT . . .

A 3-WAY CUT IN WATER-CARRYING

Johns-Manville
TRANSITE PRESSURE PIPE
JM
An ASBESTOS Product

REAL ECONOMY in water transportation begins *after* your pipe is purchased.

Any one pipe that can cut installation charges; virtually eliminate maintenance and very sizably reduce pumping costs throughout its long years of service—is a pipe that guarantees true economy as a water carrier.

A high standard, yes—but not too high for Transite Pipe, as the facts quickly prove.

INSTALLATION: Relatively light, there is a decided saving each time Transite is handled. (On all but the very largest sizes no mechanical equipment is needed.) And there is the added economy of Simplex Couplings which require no caulking and are rapidly assembled by unskilled labor.

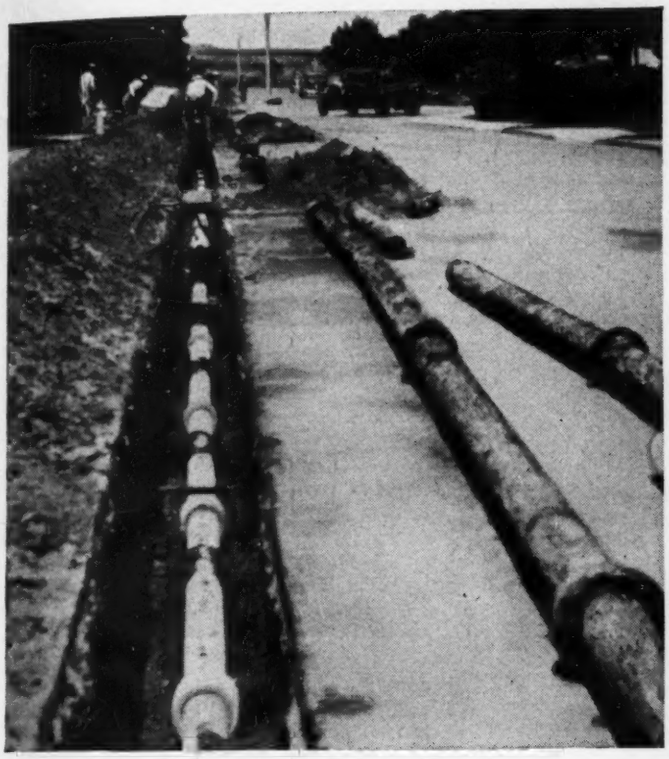
MAINTENANCE: Permanent by the very nature of its asbestos-cement composition, Transite Pipe is immune to electrolysis and tuberculation, exceptionally resistant to all corrosive soil conditions. Hence it provides a major safeguard against costly shutdowns and renewals.

PUMPING COSTS: Transite's immunity

SAVES ON MAINTENANCE . . .

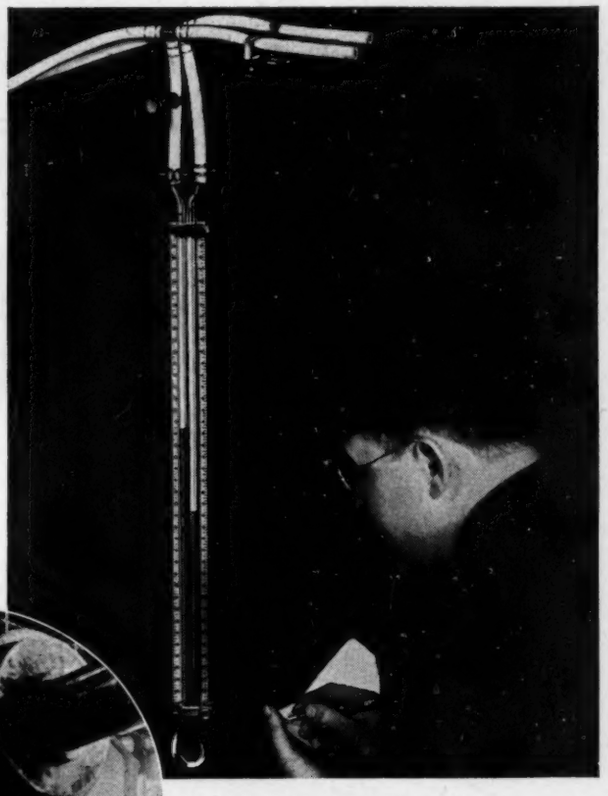
TRANSITE PIPE, because of its asbestos-cement composition, is permanent, immune to electrolysis. Cannot tuberculate. Is unaffected by acid or alkaline soil conditions. Hence, it offers freedom from cleaning expense, costly shutdowns and renewals.

(BELOW) Permanently ending the ravages of soil corrosion by installing Transite Pipe. An asbestos-cement product, Johns-Manville Transite Pressure Pipe is remarkably resistant to such destructive agencies.



SAVES ON PUMPING COSTS

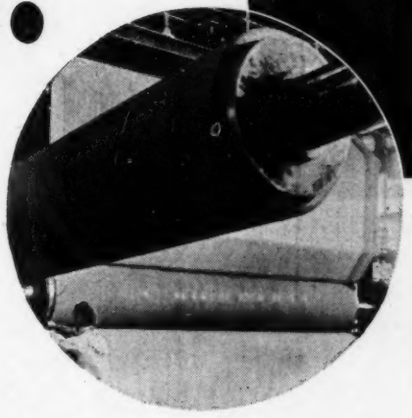
TRANSITE PIPE cannot tuberculate. Conservatively estimated, its flow coefficient is C-140—and this high initial delivery capacity is maintained indefinitely. Consider the savings possible in operating expense, the tremendous proportions they assume when you realize that it costs nearly twice as much to pump against a coefficient of 100 as against Transite's constant C-140.



COSTS!

to tuberculation gives absolute assurance that its high initial delivery capacity will be indefinitely maintained. Its conservatively estimated flow coefficient of C-140 stays pegged at that figure. And therefore, pumping costs stay permanently low.

In short, Transite Pipe effects the 3-way cut in water-carrying costs that promises you a permanently economical pipe line. Send for our illustrated brochure, covering in detail all the advantages Transite offers to water transportation. Johns-Manville, 22 E. 40th Street, New York City.



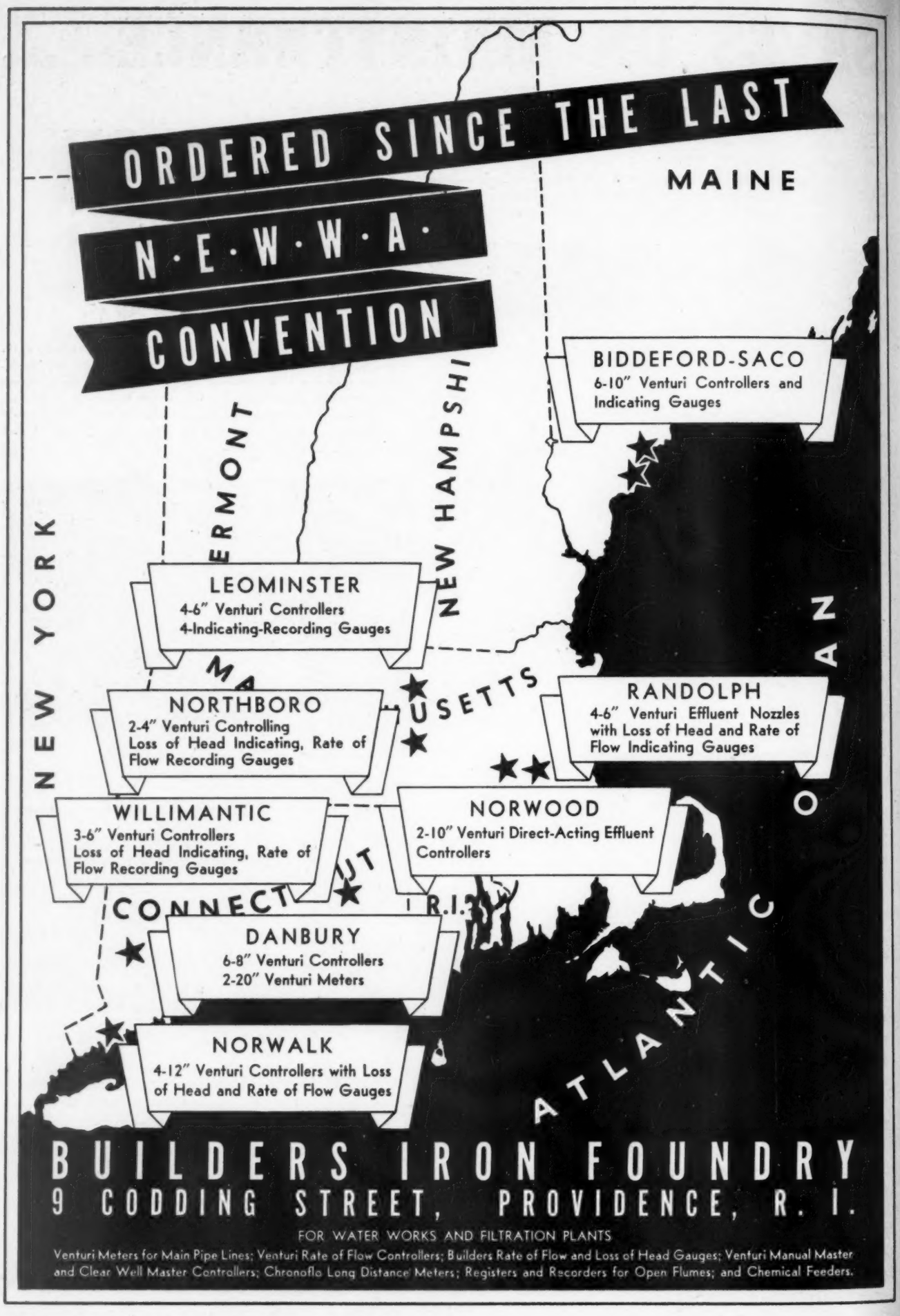
(ABOVE) "Flow coefficient 145," says the pitometer in this test of 1500 ft. of Transite Pipe from a city main into an industrial plant. **(LEFT)** One of the huge machines on which Transite Pressure Pipe is formed . . . and which is responsible for an interior smoothness that offers minimum frictional resistance to water flow.

JOHNS-MANVILLE, 22 East 40th Street, New York City
Send me the Transite Pipe Brochure.

Name_____ Organization_____

Address_____

WWS-9-36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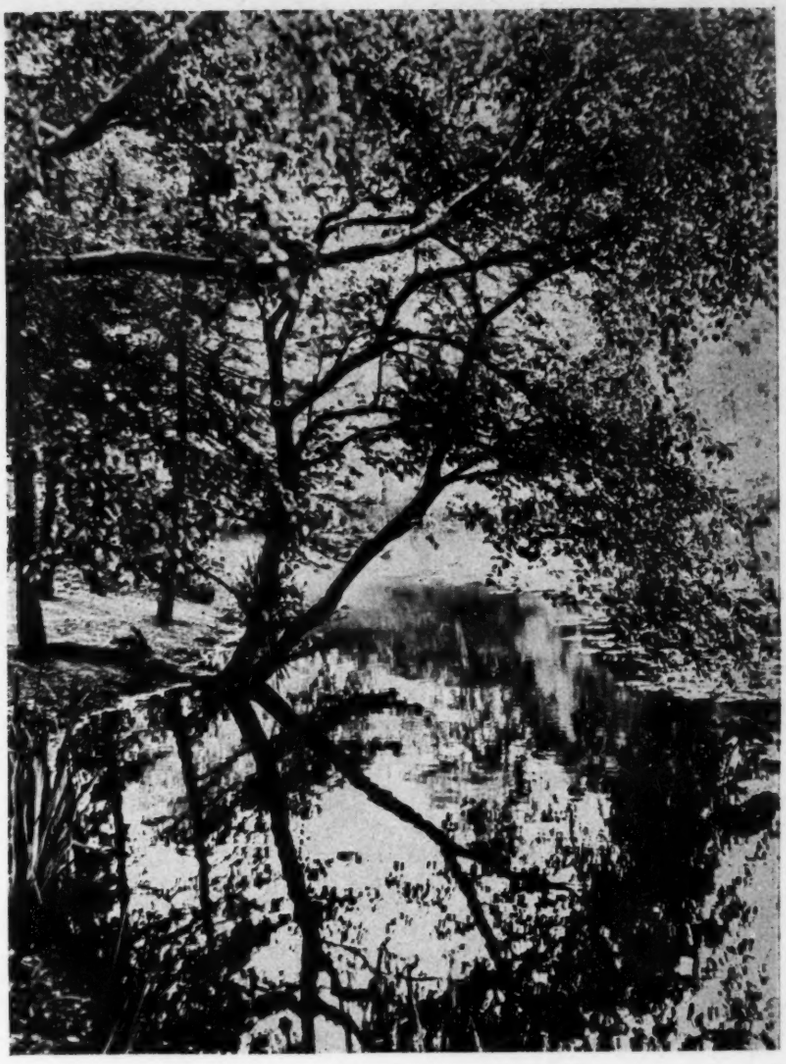
9 CODDING STREET, PROVIDENCE, R. I.
FOR WATER WORKS AND FILTRATION PLANTS
Venturi Meters for Main Pipe Lines; Venturi Rate of Flow Controllers; Builders Rate of Flow and Loss of Head Gauges; Venturi Manual Master and Clear Well Master Controllers; Chronoflo Long Distance Meters; Registers and Recorders for Open Flumes; and Chemical Feeders.



PEACEFUL NOW . . .

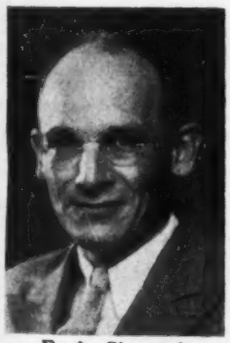
Falling leaves in water supplies cause high colors and during their decomposition create a very distinct taste and odor hazard.

NUCHAR, when fed with alum, has been found very effective in reducing economically these high colors and simultaneously the taste and odor resulting therefrom.

Decomposing vegetation during the Fall season may be similarly characterized and their removal as indicated above.

Fall rains will flush out swampy areas where the stagnant water has had an opportunity during the Summer period to leach out color, etc., from the vegetation. This swampy water makes the raw water supply more difficult to treat and possibly necessitates a larger dosage of alum.

We suggest the use of NUCHAR in the mixing chamber to obtain better coagulation and to obtain taste-free water at a minimum cost.



E. A. Sigworth
Technical Sales Staff

JOIN US AT THE NEW ENGLAND WATER WORKS ASSOCIATION MEETING, HOTEL PENNSYLVANIA, NEW YORK CITY, SEPTEMBER 22ND - 25TH.

INDUSTRIAL CHEMICAL SALES CO., INC.

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205 WEST WACKER DRIVE, CHICAGO, ILL.

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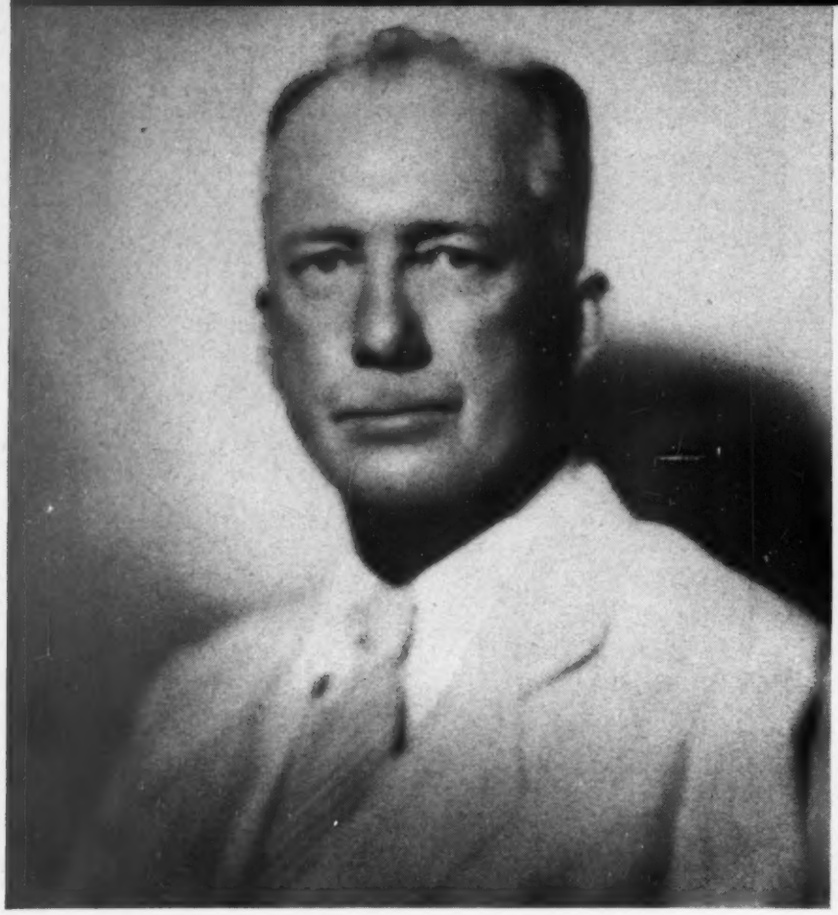
"12 YEARS OF SATISFACTION"



J. C. Martin of Tarboro, N. C., is Enthusiastic about His Experience with Mathieson Products

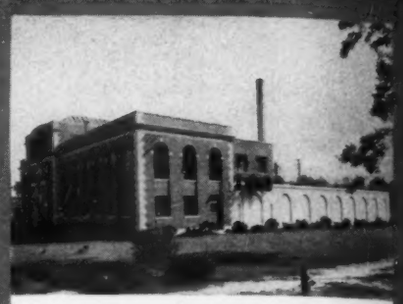
A FINER ideal of service than that of the modern water works man is hard to imagine. Few people indeed are charged with greater responsibility—few face more exacting demands for unfailing service. No wonder, then, that we see significance in what J. C. Martin, Superintendent of Public Works at Tarboro, N. C., has to say about Mathieson Products and Mathieson Service:

"We have used Mathieson Chlorine at our filtration plant since about 1923. Your service has always been prompt and the cylinders clean. We also use this product at our sewage disposal plant.

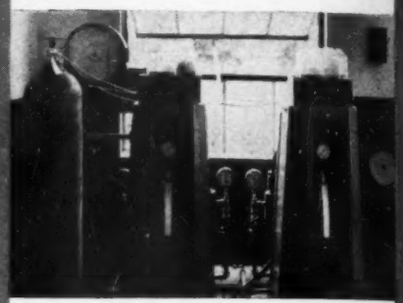
"We have used H T H and chlorine at our municipal swimming pool ever since its opening in the late summer of 1933. We treat the water in this 275,000-gal. pool with your chlorine and use H T H in foot baths and on locker room floors. We consider H T H particularly effective in pool hygiene work as we have not had a particle of trouble with Athlete's Foot or any other skin disease."

The MATHIESON ALKALI WORKS (Inc.)
60 East 42nd Street **New York, N. Y.**

Soda Ash . . . Liquid Chlorine . . . Bicarbonate of Soda . . . HTH and HTH-15 . . . Caustic Soda . . . Bleaching Powder . . . Ammonia, Anhydrous and Aqua . . . PH-Plus (Fused Alkali) . . . Solid Carbon Dioxide



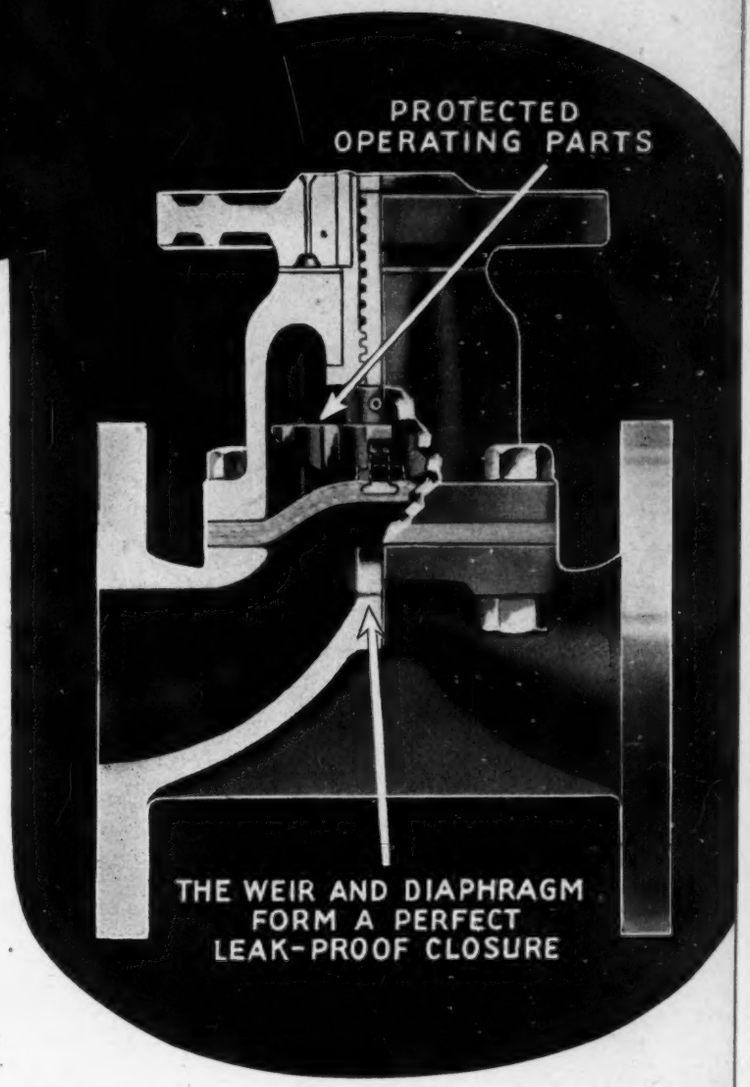
From an engineering standpoint—and in appearance—the new Tarboro Filtration Plant is the last word.



Chlorinator installation feeding Mathieson Liquid Chlorine at the Tarboro Plant.

Another view of the 1,500,000 gallon Tarboro Filtration Plant, completed this year.

The attractive Tarboro Municipal Pool where Mathieson Chlorine safeguards the water and HTH guards against Athlete's Foot.



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SAUNDERS' PATENT
VALVES

The Hills-McCanna Saunders' Patent Valve is used extensively in water works and sewage treating plants because:

- Materials handled never contact the operating mechanism—eliminating clogging—sticking or freezing.
- No accurately fitted metal to metal surfaces needed for a tight closure.
- Deposits, wire drawings, corrosion, etc., on weir (the seat of the valve) do not form leaks.
- The diaphragm used as the opening and closing medium compresses between a follower and a body weir, always providing a positive shut-off. It is moulded of tough, resilient compositions that resist wear—corrosion and erosion.
- The standard cast iron bodies and bonnet are two distinct units, requiring use of alloy castings for the body only. This feature reduces the cost of Valves made to resist corrosion.
- Bodies can be lined with glass, rubber or lead to resist chemicals, etc.
- Upkeep cost is low—no stems to pack—no seats to grind—no discs to resurface.
- Valve stays put once installed—no need of removing it from line for any repairs.

These are a few of the reasons Hills-McCanna Saunders' Patent Valves remain in service, long after other valves have failed. And, they are like new again by just replacing a diaphragm. 99% of our users report little or no maintenance over long periods and enthusiastically say, "Best valves we ever used."

Use the coupon to send for interesting Valve Bulletin which gives complete data

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Please send copy of your new Valve Bulletin.

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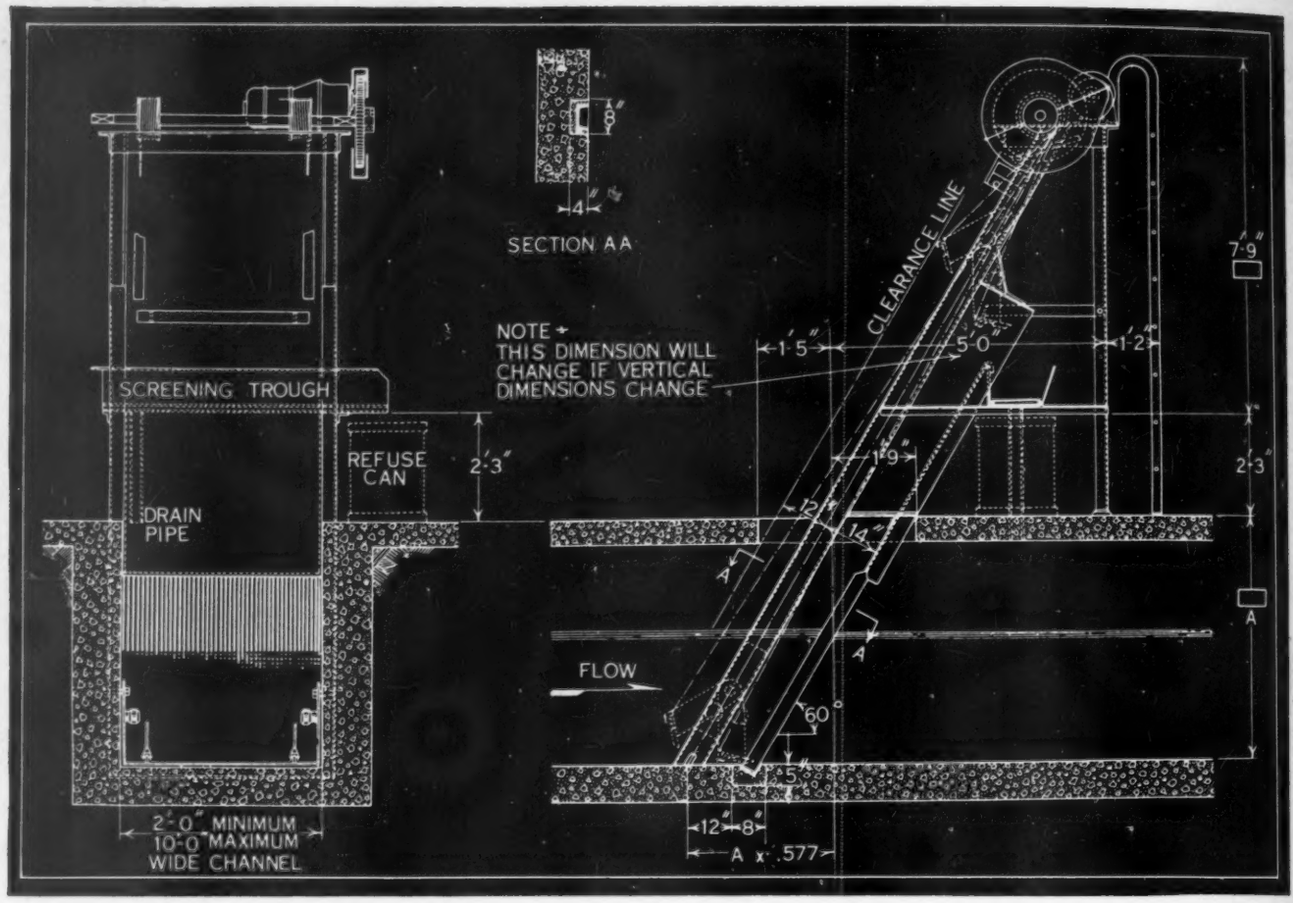
Manufacturers of CHEMICAL PROPORTIONING PUMPS • LUBRICATORS
CENTRIFUGAL PUMPS • TANK CAR OUTLET VALVES • NON-FERROUS ALLOYS

It Cannot Jam!



Inclined type Link-Belt Straightline Bar Screen. Also made in vertical type.

The STRAIGHTLINE Mechanically-Cleaned Bar Screen

The modern method of removing large suspended solids and debris from incoming sewage at both large and small plants.

All of our experience with sewage screening work, since the installation of the first Link-Belt mechanical screen in 1915, is built into the design of this unit. Its rugged, simple construction and special provisions for the avoidance of jamming assure dependable, uninterrupted operation under the most extreme conditions of service.

The mechanism for raising and lowering the rake that cleans the screen is similar to that used for raising and lowering the bucket on the skip hoist, the most reliable machine known for elevating materials. It is impossible for the rake to become jammed at the bottom, when encountering pieces of wood or other larger objects.

5785

Send for this new booklet. It contains capacity tables and dimensions. Ask for No. 1587. Address Link-Belt Company, Philadelphia, Chicago, Los Angeles, or Toronto.

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SCREENS ▲ AERATORS ▲ COLLECTORS ▲ GRIT CHAMBERS ▲ DIFFUSERS

AND ANOTHER TOROIDAL BOTTOM TANK

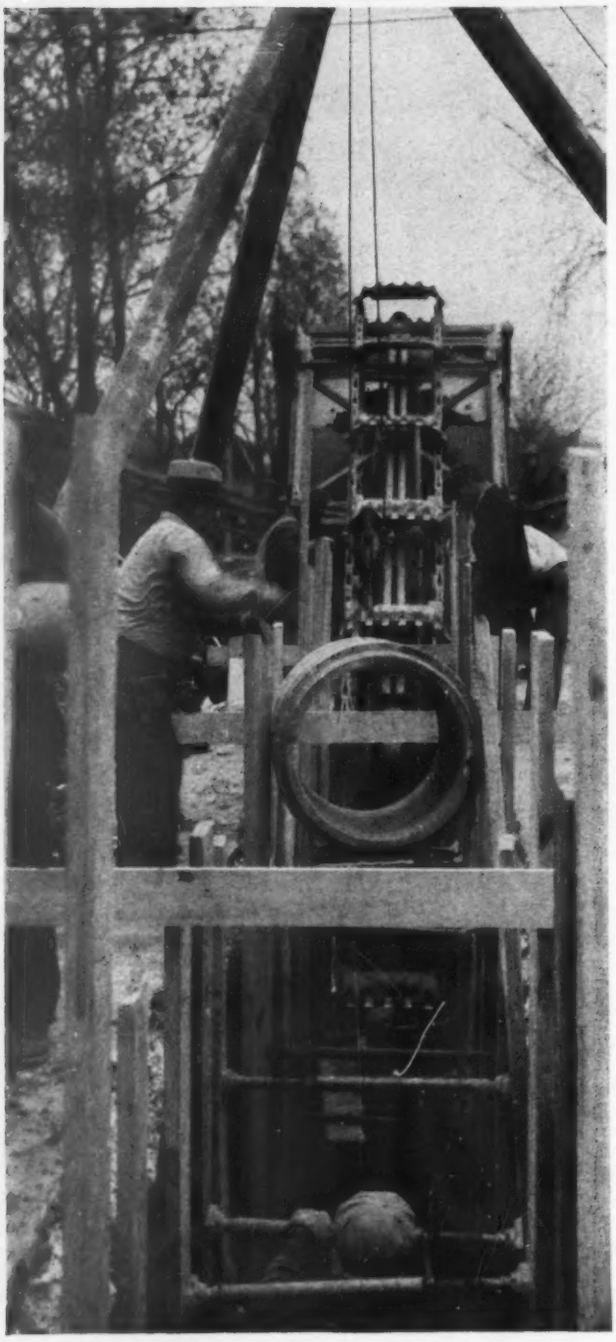
This one—at Elyria, Ohio. It is a 1,000,000 gallon tank, 84'3" in diameter, 25'0" range of head, on a tower that elevates its entire capacity 125'0".

An elevated tank is the balance wheel of a waterworks system. It provides a fixed operating head for the pumps. It guarantees water, at gravity pressure, for fire protection. It supplies water at full pressure for consumers, even during peak periods. It stands by with water to tide over periods of breakdown or power failure. It is an indispensable part of a waterworks system.

PITTSBURGH-DES MOINES STEEL CO.

Pittsburgh.....3418 Neville Island
Des Moines.....919 Tuttle Street
New York.....Room 918—270 Broadway
Chicago.....1222 First Nat'l Bank Bldg.
Dallas.....1223 Praetorian Bldg.
San Francisco.....625 Rialty Bldg.

Oak Park's New Sewerage System includes 13.6 miles of Concrete Sewers



Oak Park's PWA Project No. 1662 includes 46,310 ft. of reinforced concrete pipe 24 to 60 in. in diameter and 25,560 ft. of reinforced concrete construction—approximately 13.6 miles, 8½ miles of which is in tunnel. James A. Howe, President of Village Board; William Thomas, Village Engineer; Carey De Buttes, Commissioner of Public Works. Contractors: Michael Pontarelli, S. A. Healy and John Marsch.

IMPORTANT PROJECT FINANCED WITH SEWER RENTAL BONDS

Among recent municipal bond offerings is the $1,225,000 sewerage revenue issue of the village of Oak Park, Illinois, carrying 4% coupons. A $765,000 PWA grant increases the total improvement fund to $1,990,000. Annual interest and principal requirements, operating and depreciation charges will be met by a fixed quarterly levy against water users that is estimated to produce $103,707 annually.

Wisely, Oak Park is protecting its investment by using concrete extensively for its new sewers.

Concrete has proved its merit for all sizes and types of sewers in dozens of million-dollar programs, and in thousands of smaller projects. It is strong and durable—reduces infiltration and leakage—cuts maintenance to the minimum—is moderate in cost.

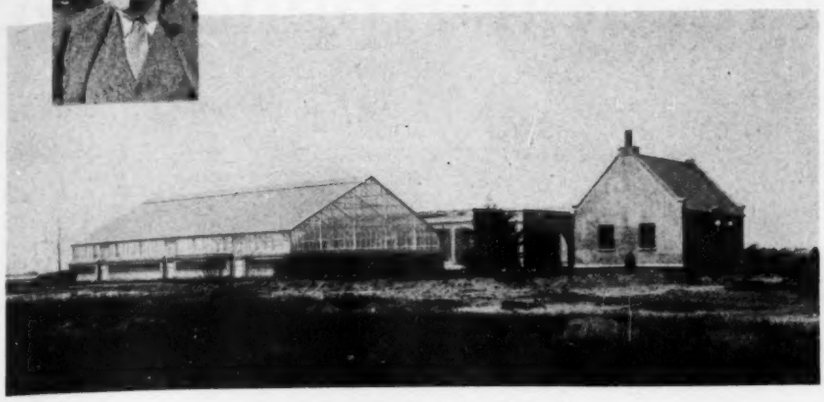
Experienced sanitary engineers in charge, plus use of concrete, assure the success of any sewer project.

For facts on the use of concrete in sewers, write for your free copies of *"Monolithic Concrete Sewers"* and *"Concrete Pipe Sewers."*

PORTLAND CEMENT ASSOCIATION
DEPT. A9-29, 33 WEST GRAND AVE.
CHICAGO, ILLINOIS

"A ROYER DISINTEGRATOR

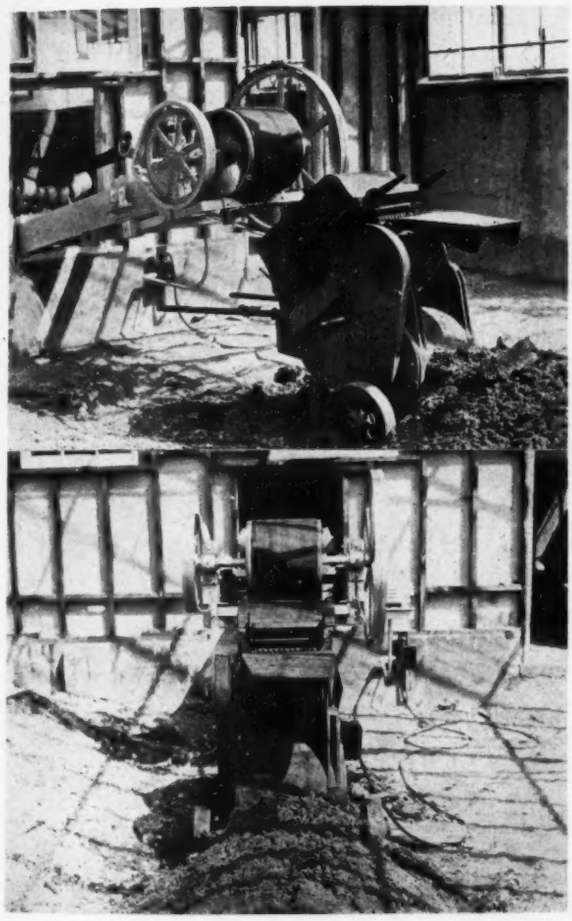
is an important adjunct to any sewerage plant"



VIEW OF FREEPORT, L. I., PLANT

So States

LAWRENCE L. LUTHER,
Mgr., Dept. of Sanitation,
Freeport, L. I., N. Y.



Machine in operation at Freeport plant handling sludge cake from vacuum filters.

A Royer Pays for . . . Itself . . .

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Reading, Pa.	Garden City, L. I., N. Y.
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AN ANSWER TO THE QUESTION:
"WHAT IS THE MEANING OF pH?"

pH *And Its* Practical Application

By *Frank L. LaMotte*
William R. Kenny
Allen B. Reed

Table of Contents

Section A. MECHANISM OF HYDROGEN ION DETERMINATIONS

I—Introduction and Preliminary Discussion
II—Hydrogen and Hydroxyl Ions
III—Buffer Action
IV—Determination of pH
V—Sources of Error

Section B. PRACTICAL APPLICATION OF HYDROGEN ION DETERMINATIONS IN INDUSTRY AND SCIENCE

VI—Municipal and Industrial Water Supply
VII—Water Corrosion Problems
VIII—Disposal of Sewage and Industrial Waste
IX—Sugar Industry
X—Gelatin and Glue
XI—Leather Manufacture
XII—Textile Industry
XIII—Pulp and Paper Industry
XIV—Food Industries
XV—Cleaning Processes
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XIX—Soils

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Cloth bound, 6x9, 255 Pages, Original Control Charts, Illustrated, Indexed.

The charts alone are well worth the price of this book.

TODAY the term "pH" is part of the routine vocabulary of almost every technical man, and the usefulness of the subject has benefited so many processes that it is now an accepted operating factor. So rapid has been its adoption throughout the technical world, that a great many routine workers now using some means of pH control do not have a clear understanding of the term "pH" itself, nor of the simple underlying principles involved in its measurement.

It is the purpose of this book to supply the need for such fundamental information in simple language, avoiding technical terms as much as possible.

Scientific men whose early training has not included this phase of chemistry and operating men will find "pH And Its Practical Application" to be a *practical* book for any reader who is not particularly interested in the theoretical aspects of hydrogen in concentration.

The broad scope of the book is indicated by the Table of Contents.

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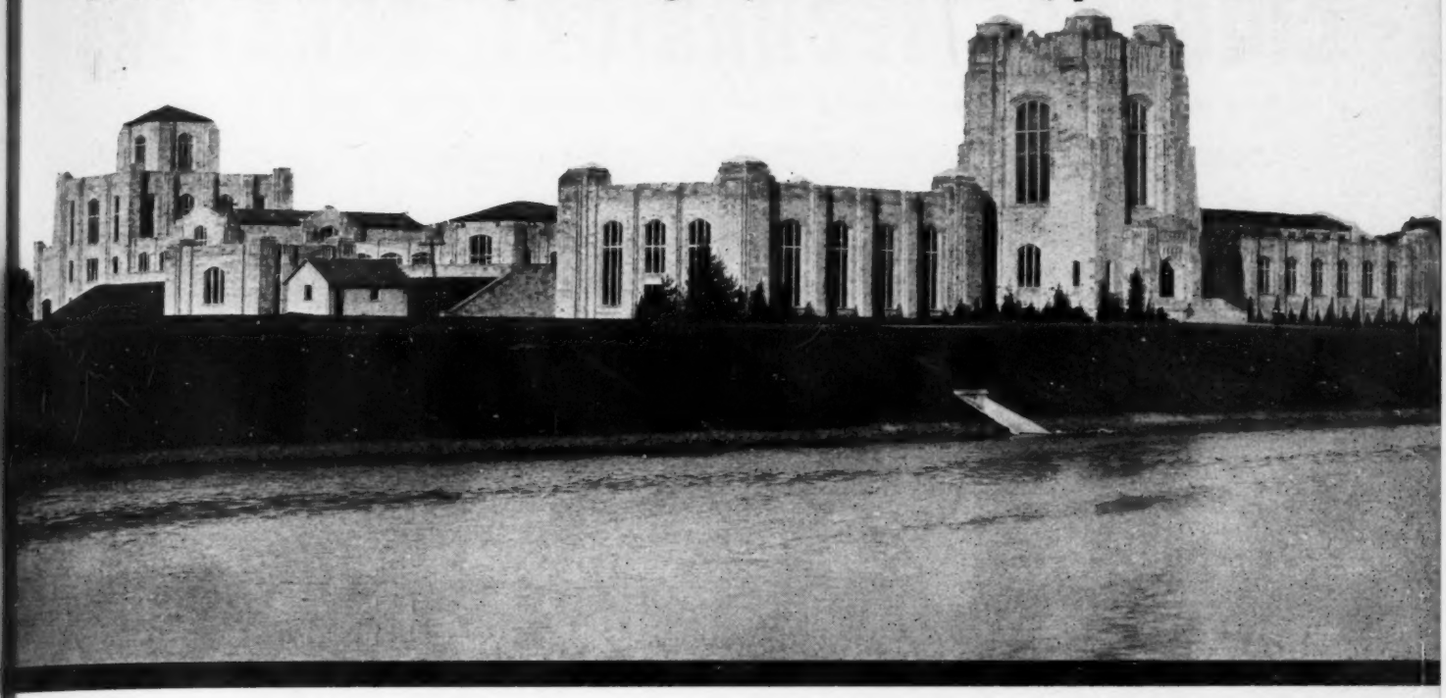

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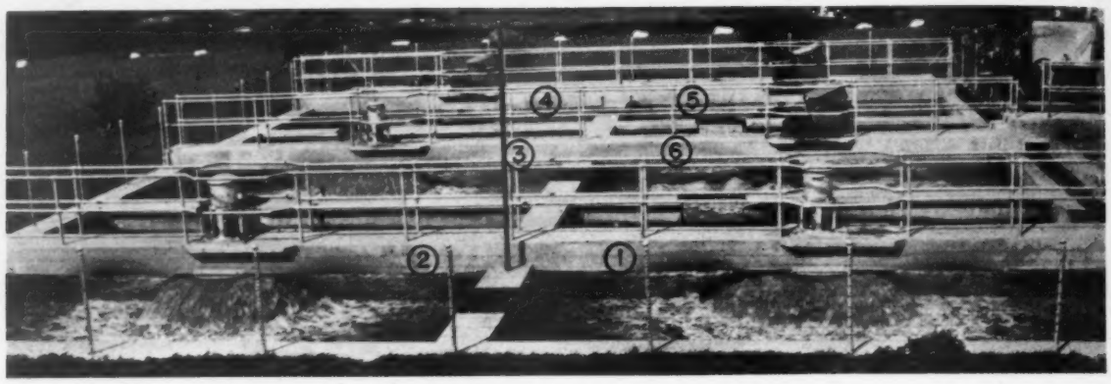

Fig. 1—Activated Sludge Plant at Monroe, showing "Chicago" Mechanical Aerators in foreground.

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2	30 to 40	MECHANICAL	5	15
3	20 to 30	AERATORS	6	15

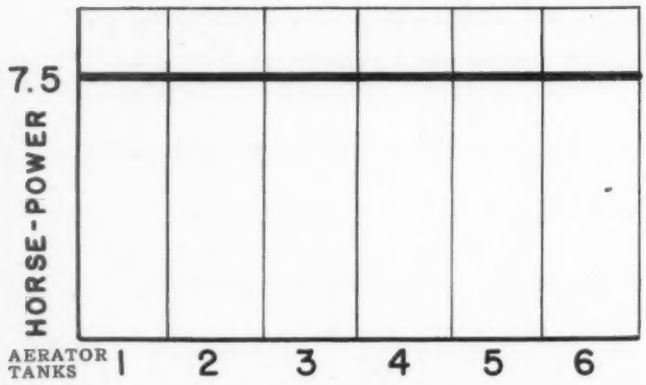

*Fig. 2—45 connected horse power would have been required to satisfy the oxygen demanded by conventional application of the six mechanical aerators at Monroe.

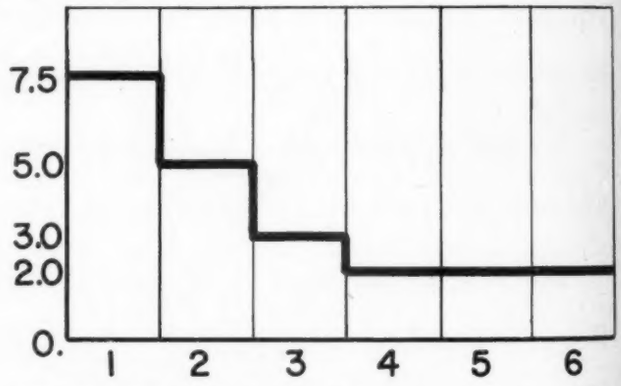

*Fig. 3—Only 21.5 connected horse power are used for successful operation of the six mechanical aerators on the Tapered Aeration principle at Monroe.

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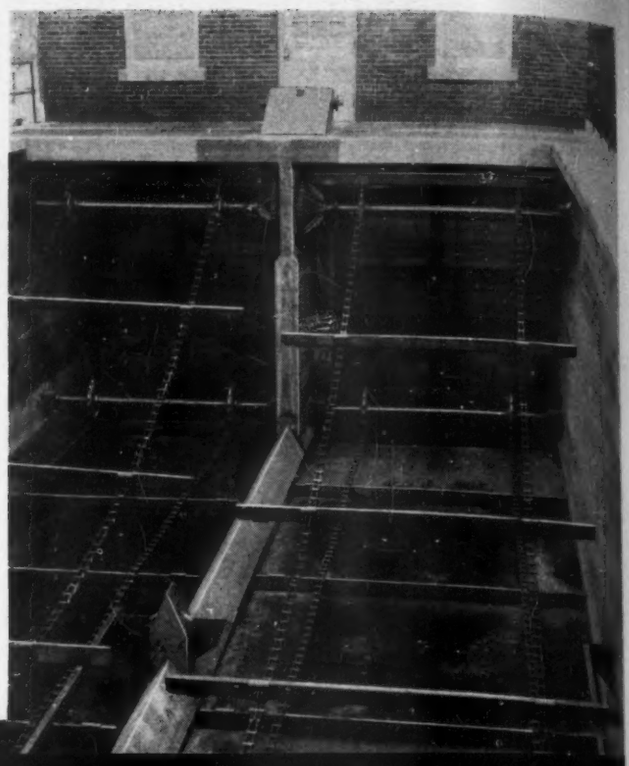

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WATER WORKS & SEWERAGE

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ARTICLES AND AUTHORS Scheduled for Future Issues

"Some Observations from Corrosion Studies"—By Charles P. Hoover, Supt. of Purification, Columbus, Ohio, reveals interesting and unexpected findings concerning water quality and resultant corrosion of household services and plumbing. In the experimental studies, dealing with waters treated by several different methods, the quality of waters assumedly of non-pitting nature have caused an unexpected degree of attack on hot water boilers and services. Other waters expected from past conceptions to be more aggressive have been the least so. The results indicate that there is much more to be learned about chemical balance for corrosion control. Water purification men will find that the Columbus observations throw a monkey-wrench into many accepted conceptions of corrosion control by water conditioning. Watch for this theory-upsetting article.

"Kinks in Operation and Maintenance"—which are being employed successfully in the Washington Suburban Sanitary District are to be incorporated into an article by Carl A. Hechmer, Engineer of Treatment and Distribution. Those who know the author, or have read his contributions will look forward with considerable interest to his forthcoming article.

"Operating Results at Durham's Activated Sludge Plant"—by W. M. Franklin, Supt. of Plants at Charlotte, N. C. (until recently Chemist in Charge of Plants at Durham, N. C.) will disclose operating experiences and results during the first year of operation of this modern and complete plant, described by W. M. Piatt in "Water Works and Sewerage" for October, 1935. The Durham plant with many novel features has become widely known for its efficient power production from digester gas; its chief problem, dealing with wastes from textile mills; its most practical demonstration, the handling of shredded garbage added to the sewers and flexibility of operating arrangements. What has been accomplished and what has been learned at Durham will be equally interesting and helpful to designers as well as operators.

"A Novel Method of Scouring and Flushing Small Mains" will be described by Richard F. Brown, Plant Manager, California Water Service Co. Practical, effective, economical; the procedure involves the simplicity of "shooting" the mains with high velocity scouring injections of compressed air followed by flushing.

"Experience With Methods of Treating Wastes from the Milk Products Industry"—by L. F. Warrick, State Sanitary Engineer of Wisconsin, long promised our readers, is assured for the next or the following issue. Those who are familiar with the marked strides made in industrial waste treatment in Wisconsin, and the many plants in operation, will appreciate the value of an up-to-the-minute disclosure of best practices and results from those treatment plants under the author's jurisdiction.

"The New Cermak Pumping Station"—as described by Loran D. Gayton, City Engineer of Chicago, which was scheduled for this issue as announced in the August issue, has had to be held for the October issue. The companion article by A. E. Gorman and H. H. Gerstein describing improved chlorinating arrangement will follow.

Vol. 83, No. 9

CONTENTS for SEPTEMBER, 1936

Aero-Filtration of Sewage and Industrial Wastes 307
By H. O. HALVORSON, Ph. D.
University of Minnesota, Minneapolis, Minn.
A.W.W.A.'s Central States Section Holds Record Meeting 314
Are You Progressing—Or Are You Worth Only Four Dollars a Day? 321
Venturi Flumes for Sewers 322
By H. K. PALMER
Chief Draftsman, Los Angeles County Sanitation Districts
What Is Clean Drinking Water? 325
By HARRY U. FULLER
Chief Engineer, Portland Water District, Portland, Maine
Experiences in Rehabilitating Large Water Mains 327
By WM. G. BANKS and A. CLINTON INGLEE
Respectively, Division Engineer, Water Department, Newark, N. J., and President and General Manager, National Water Main Cleaning Co., New York
Air Conditioning—What It Means to the Water Utility 335
By L. L. LEWIS and L. H. POLDERMAN
Chief Engineer and Western Manager, Respectively, The Carrier Engineering Corporation, Newark, N. J., and Los Angeles, Calif.
Rules for Safety 340
By SIDNEY S. ANTHONY
Superintendent Water Department, Augusta, Maine
Ventilating Manholes by Hand Blower 341
By E. T. CRANCH
Manager, New Rochelle Water Co., New Rochelle, N. Y.
Operating an Activated Sludge Plant to Prevent Sludge Bulking .. 342
By C. GEORGE ANDERSON
Supt., Sewage Treatment Works, Rockville Center (L. I.), N. Y.
On Cooperation Between Water and Fire Departments 345
By SHERWOOD BROCKWELL and SELDEN ALLEN
Respectively, State Fire Marshal, Raleigh, N. C., and Chief, Fire Department, Brookline, Mass.
Evaluating Treatments for Eliminating Taste and Odor 347
By OSCAR CULLANS
Senior Sanitary Chemist, Division of Water Purification, Chicago, Ill.
Raw Water Preparation vs. Filter Design 350
By MARSDEN C. SMITH
Engineer, Water and Electricity, Richmond, Va.
Operation of New Sewage Treatment Plant at Williamsburg, Va. .. 352
By A. L. MEISIL
City Manager, Williamsburg, Va.
Screw and Propeller Pumps Meet With Favor on European Works . 354
By C. H. S. TUPHOLME
London, England
Federal Aid in Retrospect and What's Ahead 355
Comparative Fire-Protection Value of Distribution Systems 356
By CHARLES H. CAPEN
Senior Assistant Engineer, North Jersey District Water Supply Commission
New Functions for the Hydraulic Laboratory 360
By GEORGE E. BARNES
Professor of Hydraulic and Sanitary Engineering Case School of Applied Science
Editorial 364
Equipment News and Literature Review 84

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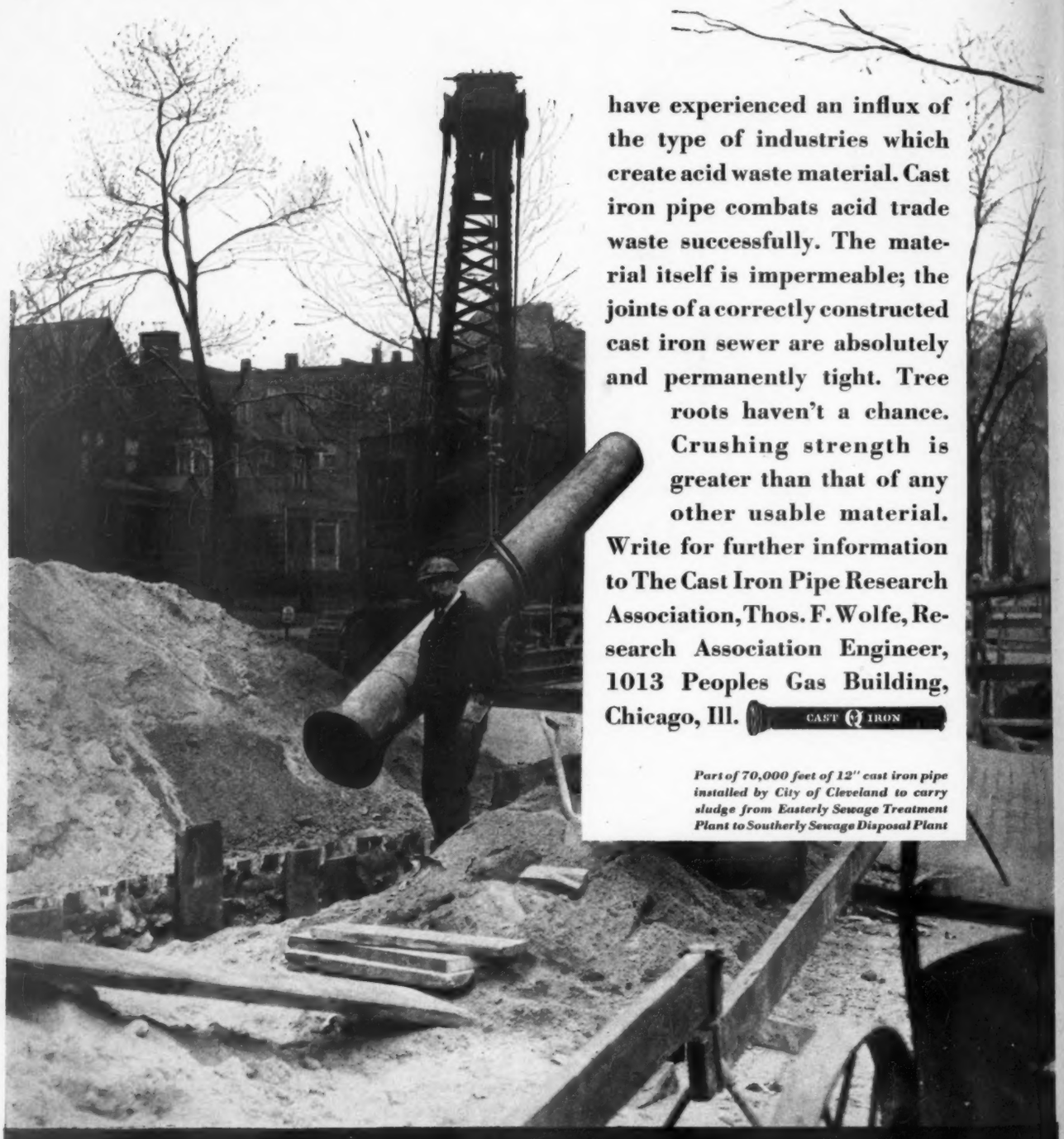

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WATER WORKS AND SEWERAGE

A GILLETTE PUBLICATION

VOL. 83 SEPTEMBER, 1936 No. 9

AERO-FILTRATION OF SEWAGE AND INDUSTRIAL WASTES

By H. O. HALVORSON, Ph.D.*

University of Minnesota, Minneapolis, Minn.

Dr. Halvorson

OUR investigations of the trickling filter during the past few years have led us to the conclusion that trickling filters can be dosed at much higher rates than are commonly used. Before presenting our own evidence and data, allow me to review briefly current practices in connection with the design of these filters.

Current practice dictates that these filters should be from 6 to 8 ft. deep. The filtering medium should be rock graded from a minimum of ¾ to a maximum of 3 inches. Underneath the rock, underdrains are provided to carry away the water and allow for aeration. The typical American filter is dosed by means of fixed nozzles on top of the bed, sufficiently far apart so that the sprays from adjoining nozzles about touch. This is considered good practice even though it is difficult to fit round sprays into rectangular beds. In recent years, some of the objections to fixed nozzles have been overcome to a certain extent by the use of rotary distributors which, because they provide better distribution, also bring about some saving in filter area. In either case, dosage is intermittent. According to current teaching, intermittent operation is essential for successful operation. There is considerable variation in the length and number of rest periods, but usually the filter is allowed to rest at least half the time. In many plants, however, the rest period is very long, and occupies considerably more time than the dosing period. For example, in a recent construction, the filter is dosed for 5 minutes and rests for 60 minutes.

Standard practice also dictates that the bed should be dosed at rates from ½ to 4 million gallons per acre of surface per day. It has been universal experience that all dosages above this that have been tried have resulted in plugging or ponding of the bed. This shuts off the air supply and results in very inefficient operation. In standard designs, the filter is preceded by a dosing tank operating by means of a siphon. The bed rests while the tank is being filled, and is dosed as the tank empties. With fixed nozzles, distribution is effected by making use of the variation in head in the dosing tank. When the head is high at the beginning of the dosing cycle, the spray is thrown the farthest; as the head is lowered the spray pulls in, dosing the rock near the nozzle. Although it is impossible to get uniform distribution by this principle, it is not generally believed that this is a deficiency of any great importance. It is assumed that as the liquid passes down through the bed, it spreads out in the form of a cone, and, even though the distribution is not perfect on the top, it becomes more even as the liquid flows through the bed. Most beds are so constructed that the air which is needed can pass through. Although some provision is made for this aeration in the design, it is not considered of sufficient importance to require special consideration. It is generally assumed that aeration is automatically taken care of by the intermittent dosage. For, in dosing the liquid replaces the air; in the rest period the air replaces the liquid.

Some Comments in Review

These standard practices governing the trickling filter intrigue the research man very much because they do not appear to be founded on fundamental principles. If they are, the fundamentals are obscured by the lack of adequate and pertinent data. The rest period cannot be justified from modern teaching in biology. Bacteria are not like men in that they need feeding rest between meals. In fact, experience in bacteriology shows that microorganisms grow faster and thrive better when fed continuously. Certainly, periodic rests should not improve their growth in the filter bed. Common sense of hydraulics would teach us that better results are to be obtained by distributing the liquid over the bed all the time in the form of a light flow than by suddenly dumping large volumes of waste and following this with a long rest period. Perhaps the intermittent dosage is necessary for proper aeration. If this is the case, the underlying principles are obscure and do not follow obvious teachings of aerodynamics. Can it be that practices in vogue for trickling filters are based entirely on mechanical considerations? It is, of course, true that a continuous dosage involves some mechanical difficulties. Perhaps an improvement in the mechanics that would allow us to operate the filters in accordance with sound principles of bacteriology and hydraulics would greatly improve the efficiency and capacity of trickling filters. If this is so, we may be allowing a lack of mechanical ingenuity to so increase the cost as to make one of our most reliable units and methods of sewage treatment almost prohibitive.

Let us therefore review the history of the develop-

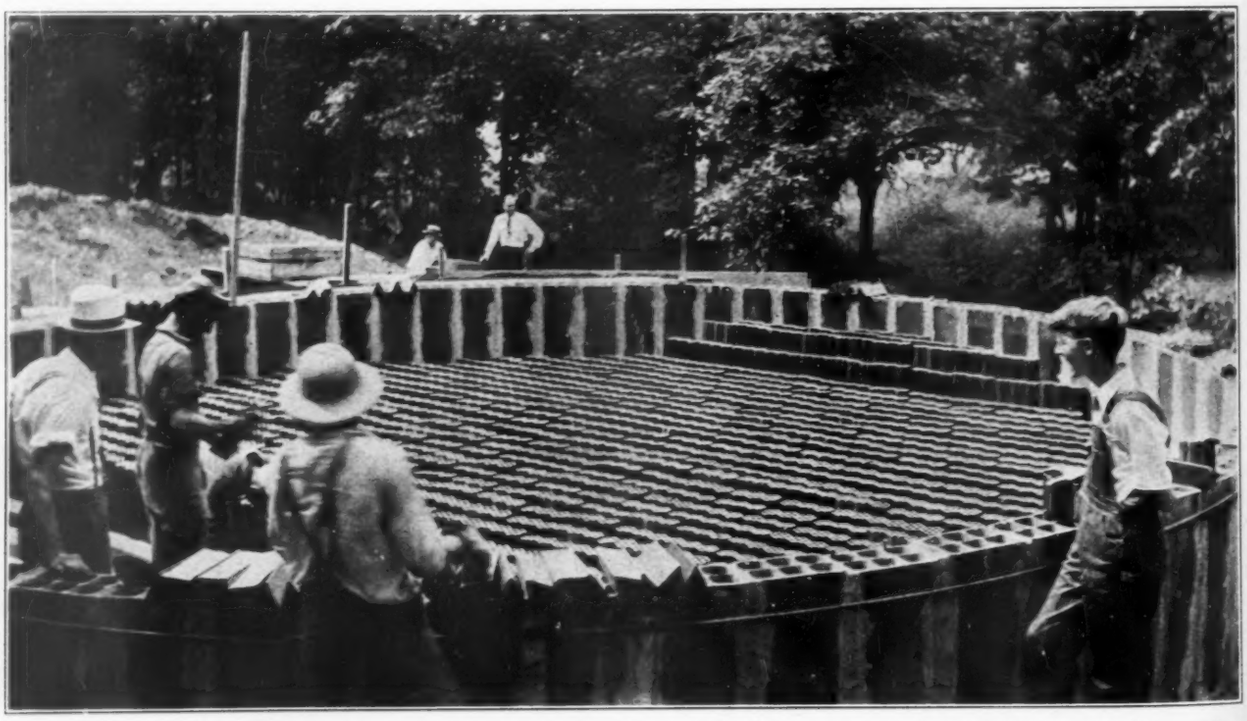
*Department of Bacteriology and Immunology.

ment of the trickling filter to see what underlying principles have been established. The first trickling filter ever built was one designed by Bailey Denton at Birmingham, England, in 1871. This plant was built upon the recommendation of Sir Edward Frankland[1], and was referred to as the intermittent downward filtration bed. It was essentially the trickling filter of today, with soil instead of rock as the filtering medium. It was an improvement over the old method of sewage farming that had given so much trouble from clogging and ponding. Frankland believed that, by putting in an under-drainage system and using intermittent dosage, ponding could be overcome. The first filter constructed at Birmingham was dosed with from 6000 to 10,000 gallons per acre per day, and at this rate operated successfully for a period of forty years. Upon constructing plants of a similar type in other localities, it was learned that the nature of the soil had considerable effect on the allowable dosage. Sandy soil could take considerably more waste than clay.

The work of Frankland was expanded by the famous experiments at Lawrence, Massachusetts[2], where careful studies were made on all known methods of sewage treatment. One of the important developments was the discovery that rock or cinders would purify sewage just as well as Frankland's intermittent filtration bed. It was also found that beds constructed of this material could be dosed at much higher rates, but that as the size of the filtering medium was increased, the problem of distribution became more and more important. With a fine medium such as sand, the entire surface of the bed could be flooded, and good distribution would be obtained as the liquid trickled through the sand. With coarse medium, most of the liquid passed rapidly through certain portions of the bed, while other portions received none.

The experiments at Lawrence were expanded by the investigations of two English engineers, Sir Alexander Binnie[3] and Mr. Joseph Corbett[4]. Both men attempted to improve upon the results obtained at Lawrence by solving the problem of distribution on beds of coarse media. Binnie found that the problem could be eliminated by completely filling the voids in the bed. He closed the outlet and allowed the waste to stand in the bed for a period of time before draining it out. This contact method gave results comparable to those obtained at Lawrence. For the successful operation of such contact beds, a rest period was absolutely essential. In such beds, also, the air does replace the liquid which leaves the filter, and the liquid in turn replaces the air. Later experiments with the contact bed showed that the efficiency of treatment was improved as the number of dosing and resting periods was increased. Naturally, the shortness of the cycle is limited by the length of time required to fill the bed and drain it. To shorten the cycle still further means an overlapping of the filling and draining periods, which of course leads us right back to the trickling filter, and reopens the problem of distribution. Although the experimental work preceding the trickling filter did not originate with the contact bed, the precedence in design and operation of the modern trickling filter was apparently established by the contact bed.

Corbett tried to solve the problem of distribution in filters using coarse media by several methods. One was to cover the coarse medium with a layer of fine sand so that the bed could be flooded and the liquid allowed to percolate through the sand which thus served to distribute the waste evenly over the coarse medium beneath. This was not successful. With the dosage he used, the sand soon ponded and had to be raked or washed with a countercurrent of water. He next developed a special type of sprinkling nozzle that would give a fairly uniform distribution over the entire surface covered by this nozzle. The orifices in the nozzles were so designed that the liquid was given a twirling motion which served to break up the waste into fine particles. The filter contained a series of these nozzles set far enough apart so that the spray from one just touched the spray from the other. The filter medium



Tile Filter, 25 Ft. Diameter. Now Under Construction for Treating a Mixed Domestic and Industrial Sewage in Community of 3,000 Population.

Aero-Filtration Plant for Community of 3,000 Population. Final Clarifier in Foreground; Filter and Pump House Beyond.

varied in size from 1/6 to ½ inch. By using sprinkling nozzles and continuous dosage, the beds could be operated successfully up to a rating of 7 million gallons per acre per day. Corbett found that if rates higher than 7 million gallons per acre per day were used, the bed ponded.

Following the work of Binnie and Corbett, Candy and Caink[5] introduced the idea of a dosing tank (1898), and incorporated in their process the principle of intermittent dosage as an aid in securing good distribution. Most distributors used at that time involved orifices that had to have a somewhat constant head in order to give constant dosages; therefore, in order to make the available flow operate the distributors successfully, Candy and Caink used the dosing tank as a storage chamber when the flow was light. We see from this that the intermittent principle was introduced as a mechanical aid, and not as a feature essential to the proper biological functioning of the filter bed. In fact, Corbett's experiments had demonstrated that the bed would work efficiently when dosed continuously.

The following facts seem to have been established by these early investigations:

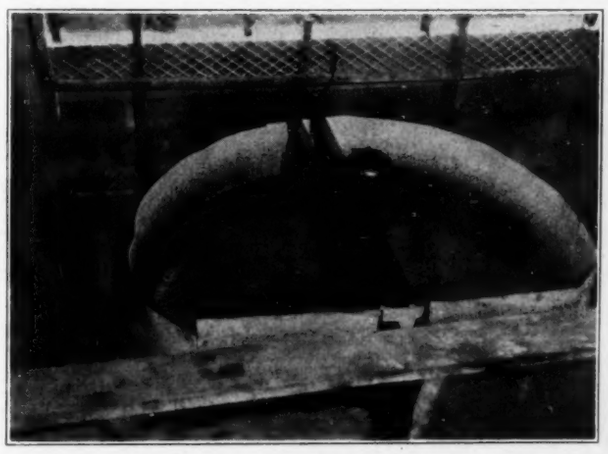
1. The finer the filtering medium, the more easily is the bed ponded. Thus the maximum dosage is comparatively low on beds of soil or sand. But even with filtering medium as fine as 1/6 to ½-inch, a dosage as high as 7 million gallons per acre per day can be used.
2. A trickling filter will operate successfully with no rest periods.
3. The coarser the medium, the more accurate the problem of distribution.

The early work does not indicate that a fine medium gives any better results than a coarse medium, providing the problem of distribution is taken care of where needed. These early investigations give no information about the amount of air needed, or the conditions which bring about the flow of air through the filter. They do not show the relation between rate of application of waste and percentage reduction.

Two pieces of recent research conducted in this country have a particular bearing on the latter problem. The one is a survey made by the late Childs[6], who analyzed data from the major trickling filters in the United States, observing in particular the effect of dosage upon the percentage of purification. He concluded that the percentage of purification was independent of the rate of application, and recommended that filters be dosed at much higher rates than the current practice. Somewhat contradictory conclusions were reached by Levine[7] from his investigations. He studied intently a small laboratory filter that was dosed intermittently by means of a tip trough. The discharge from the filter naturally fluctuated with the dosage cycle. He measured the rate of flow of effluent from the filter at short intervals, taking a sample for B.O.D. determination at each measurement. During periods when the flow of effluent was very light, the B.O.D. was low; whereas, when the effluent flow was heavy, the B.O.D. was much higher. However, even at periods of maximum flow, there was a considerable reduction in the strength of the sewage. This indicates that the rate of flow through the filter does influence the percentage of reduction. There is apparently a discrepancy between the conclusions of Childs and those of Levine.

Observations and Deductions

In an attempt to explain this contradiction, we made a few observations of our own which led to the present development. We had an opportunity to study a trickling filter employing a rotary distributor. When the distributor arm was blocked so that it could not turn, thus increasing the flow through a particular portion of the bed, the percentage reduction in B.O.D. decreased. When a large volume of creamery waste was diverted into the plant so as to increase the total flow through the filter, with the distributor running continuously, the percentage reduction was the same as when a smaller volume of waste was flowing through the plant. This apparently explained the discrepancy between the observations of Childs and Levine. When a larger volume flows through the plant, the rest period is cut down while the rate of flow through the filter remains unchanged. Consequently, increasing the quantity of waste going through the filter without changing the velocity of the distributor or the size of the orifices in the fixed nozzles does not alter the actual rate of application, and therefore no change is noted in the degree of purification. However, if the distributor arm is blocked, the rate of application through a portion of the bed is increased, with a resulting decrease in the amount of purification. Thus, with a constant volume of liquid, the degree of purification can be increased by increasing the speed of the distributor; or, with an increased volume of liquid, the degree of purification can be kept constant by bringing about a corresponding increase in the speed of the distributor. The ideal situation would be created by a distributor giving a uniform rain-like dosage over the entire bed at all times, thus providing, for any given volume, the least possible instantaneous dosage. An ordinary rotary distributor, going at the rate of two revolutions per minute, established an in-



Lake St. Filter No. II. Diameter, 6 ft. Media: Tile. Dosage: 20 MG/Acre/Day

stantaneous dosage which results in a purification of from 90 to 94 per cent. It would appear from this that it should be possible to increase immensely the capacity of trickling filters.

While making the above observations on a plant with a rotary distributor, I also noticed that there was a pronounced unloading at the beginning of each dosing period; after the distributor had reached its normal speed, there was little, if any, unloading. It naturally takes some time for the mechanism to reach its normal velocity, and during this time the rate of flow through the portion of the bed which is being sprayed is greater than it is when the distributor is in full motion. This heavier flow apparently brings about a marked increase in unloading. From this observation grew the theory that rate of flow might have an important effect on the unloading of a filter, and that a bed dosed continuously with a rain-like spray might function efficiently at rates sufficiently high to provide a flushing action to wash out the accumulated slime or sludge, even though, under the same conditions, the bed might pond at lower rates of application.

Experimental Work

To test this theory we constructed a small experimental plant at one of the municipal sewer outlets in Minneapolis. The plant, which has been called the Oak street plant, consisted of a settling tank large enough to give a theoretical detention of two hours and a filter of 8 ft. in diameter filled to a depth of 8 ft. with crushed granite graded from 1½ to 3 inches. The sewage was pumped into the primary settling tank from which it flowed by gravity to a disc distributor placed on top of the filter. The distributor was operated by means of the hydraulic head, and the rate of flow was controlled by means of an orifice placed directly beneath the disc. On the under surface, and set at an angle to the radius of the disc, were several impellers which, when hit by the water, imparted a rotary motion of the disc, thus providing a rain-like spray over the surface of the bed. By adjusting the angles of the impellers, it was possible to effect any given distribution. The bed was dosed continuously.

The plant was put into operation in the spring of 1934, with a dosage of 10 million gallons per acre per day. After 3 weeks at this rate, the filter was completely ponded. We then increased the rate of application to 26 million gallons. After a month at this dosage, all signs of ponding had disappeared and there was marked improvement in the percentage purification. During the subsequent two months, we had a steady increase in the degree of purification, achieving finally a 90 per cent reduction in the 5-day B.O.D. It was possible, however, that the ponding we had experienced earlier had been more or less accidental, and quite independent of the rate of dosage. We therefore returned to the 10 million gallon dosage in the fall of 1934. For the first week, the percentage purification increased, but after that it fell off steadily. After three or four weeks, there were indications of ponding, and after another three weeks, the bed was completely plugged. This experience, it seemed, confirmed our theory, but we later encountered other difficulties which cast some doubt on the validity of our conclusions. When, for the second time, we increased the dosage to 20 million gallons per acre per day, we were unable, at any time during the following winter, to achieve successful operation. (See Table I.) However, in the spring of 1935, the bed again began to function at a dosage of 20 million gallons, and operated efficiently throughout the summer. These experiences raised the question of whether the ponding which occurred at a dosage of 10 million gallons was a result of low dosage or of low temperature.

Also, during the fall and winter, the growth of Fusaria in the plant was a source of much difficulty. The Fusariae are molds which are common in soil and which reproduce under water by means of cigar-shaped spores. These molds not only grew on the rock but clogged our pipe lines and pump, and at one time, when the primary settling tank was not cleaned for a period of a month, they filled about two-thirds the volume of the tank; at the same time that the Fusariae first appeared, there was a change in the color of the raw waste. Upon investigation, it became apparent that the waste from this particular outlet was largely from a malting plant. The question then arose as to whether the ponding which had occurred in the spring of 1934 might not also have been caused largely by molds.

Then, too, in the fall of 1934, when we were for the second time trying to obtain successful operation at a 20 million gallon rate, we discovered that there was practically no draft through the filter. During the summer when the plant was working well, there had been a distinct downward draft, as evidenced by the flow of smoke generated at the inlet and outlet of the filter. When Dr. Levine, in one of his experiments, deliberately blocked the air outlet of a laboratory filter, ponding resulted. Dr. Levine has concluded that aeration is a factor of primary importance in control of ponding. It is possible that the ponding we experienced in the spring and fall was due to lack of adequate aeration.

TABLE I—OAK STREET PLANT

Monthly Averages

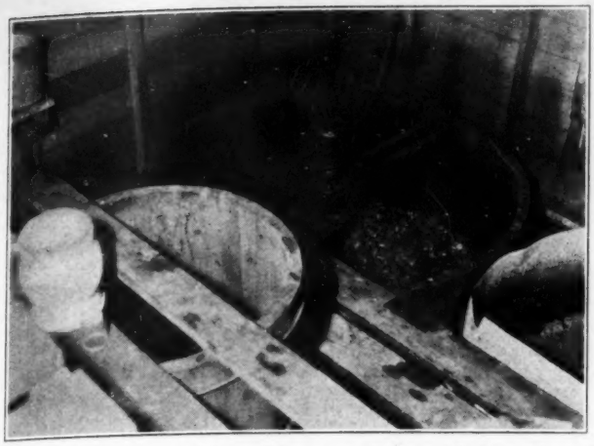
1934	*5-day B.O.D.* Influent	Effluent	Percentage reduction	*Rate* m.g.a.d.
June	193	84	56	26
July	169	30	82	26
August	172	12	92	22
September	128	30	77	10
October	151	53	65	25
November	208	113	55	20
December	187	109	42	..
1935				
January	196	107	46	..
February	129	73	44	..
March	105	49	58	..
April	202	119	42	..
May	242	129	47	20
June	236	47	81	20
July	208	15	92	20
August	165	14	91	20
September	208	66	69	20

Air Flow Studies

In the light of these observations, we decided to adopt the following plan of procedure:

1. Make a study of the factors responsible for the flow of air through a filter in order to determine whether or not forced draft is necessary.
2. Construct another experimental plant at a sewer which does not carry malting plant waste in order to determine whether our difficulties were a result of the method or a result of the particular type of waste treated.
3. Repeat the experiments over an entire year to determine the effect of temperature upon the degree of purification.
4. Find ways and means of controlling the growth of Fusariae.

The air flow problem was studied on a separate filter constructed in the laboratories of the Department of Chemical Engineering at the University of Minnesota. The filter was 3 ft. in diameter and 6 ft. deep and was



Lake St. Filter No. III. Diameter, 6 ft. Media: Gravel, 1½-3 in. Dosage: 20 MG/Acre/Day

filled with gravel having an average diameter of 1¾ inch. It was equipped with a rotary distributor. Dosage could be varied from 2 to 30 million gallons per acre per day. A hot wire anomometer was used to measure the volume of air flowing through, while the temperature of the air, the filtering medium, and the liquid were measured by means of thermo-couples. The results of this study will be published later; suffice it to state here that the only factors causing air to flow through a filter of this type are the difference in the temperature of the air and the liquid, and the difference in humidity of the air in the filter and the air outside. If the air is warmer than the liquid, it is subjected to contraction, which results in a downward flow of the air; if the air is colder than the liquid, the resulting expansion brings about an upward flow of air. At dosages above 10 million gallons, there is a straightline relationship between the rate of flow of air and the difference in temperature of liquid and air. At dosages below 10 million gallons, this relationship no longer holds. At low dosages, the air flow is much less than it should theoretically be, which indicates that under these conditions, the filter acts as an inefficient cooling tower.

With the particular filter on which these studies were made, a flow of 1 cu. ft. of air per square foot of surface was obtained with a difference in temperature of 7 deg. F., when the dosage was above 10 million gallons per acre per day. At dosages below 10 million gallons, the air flow was erratic and unpredictable. These experiments indicate that filters should be provided with forced draft during those seasons of the year when temperatures of air and liquid are nearly equal, i.e., during the spring and fall. The question naturally arises as to the quantity of air needed. Calculations of the actual amount of oxygen required to oxidize the organic matter entering a filter indicate that only a comparatively small volume of air is needed; however, studies on gas adsorption, towers have shown that the important factor is the rate of adsorption, which, in turn, is a function of the differential velocity between the liquid phase and the gaseous phases. Therefore, to bring about adsorption of oxygen by the water, we should have a fair velocity of air through the filter. To insure such a velocity, we have arbitrarily set a minimum of 1 cu. ft. of air per sq. ft. of surface per minute as the desirable minimum when forced draft is used. A smaller amount than this may be adequate, but the power cost involved in moving this quantity of air is so small that it would scarcely seem worth while to install equipment for a lesser volume.

As an additional preliminary experiment, we installed another small laboratory filter, 8 inches in diameter and 4 ft. deep, filled with gravel of an average diameter of 2 inches. The filter was dosed continuously by a jet flowing onto a splash plate on top of the bed. The waste was a weak solution of milk of such strength as to give a 5-day B.O.D. of about 250 p.p.m. The filter itself was built of glass tubing which enabled us to observe the behavior of the fluid as it passed through. Even though the top layer was sprayed more or less uniformly, channels were soon formed down through the bed. Sometimes fully 90 per cent of the total dosage passed through a single channel, and at other times the waste was more or less evenly divided between a half dozen channels. The percentage of purification depended to a large degree on the number of individual channels formed. (See Table II.)

At all times, a large percentage of the rock surface was dry, even when the bed was dosed at 20 million gallons. We also inoculated the filter with effluent from a municipal treatment plant, in order to seed fly larvae. The flies lived and bred on the dry portions of the rock, and did not go near surfaces that were wet. This had an interesting bearing on our experience at the Oak street plant. During the time the plant was in operation, there were no flies in evidence, but when the plant was shut down for a period of a half hour or more, flies came up from the interior of the bed in very large numbers. It is apparent that even though the filter was being dosed at a high rate, a large portion of the rock surface was dry. This provides a good clue as to the method of controlling fly nuisances: continuous dosage which keeps the surface wet at all times will prevent flies from escaping from the interior of the bed.

TABLE II—MEASUREMENTS OF FLOW AND B.O.D. VALUES IN CHANNELS THROUGH FILTER ROCKS

	5-day *B.O.D.*	% of *Flow*	1-day *B.O.D.*	% of *Flow*	1-day *B.O.D.*	% of *Flow*
All influent	235	..	105	..	99	..
Channel A	222	35	70	45	15	50
Channel B	215	35	40	35	2.5*	..
Channel C	137	25	12	15	..	..
Channel D	20	5	3	5	..	..
Composite	190		54		10	
Calcium composite...	191.7		57.45		8.75	

*10-12 other channels

Our observations on the small laboratory filter also indicated that the efficiency of a trickling filter could be greatly improved by using a medium designed to prevent channeling. Therefore, we got in touch with a manufacturer of sewer pipe, and made arrangements to have made a specially designed tile. The glass filter had revealed that the crevices between the rocks became frequently filled with humus or partially digested sludge; from some portions this would be washed away; from other portions more or less inaccessible it would remain rather permanently. The specially designed filter medium should eliminate this difficulty by making unloading easier. In Table III are given results obtained on a small laboratory filter using this tile as a medium. The filter was dosed with milk waste at the rate of 16 million gallons per acre per day.

TABLE III—EXPERIMENTAL TILE FILTER

Date	5-*day B.O.D.* Influent	Effluent	Percentage *reduction*
June 5	823	86	90
July 23	1192	129	89
August 5	1075	130	88

Lake St. Experimental Plant

In the new Lake St. experimental plant built in the summer of 1935 we made three separate filters, each provided with its own preliminary settling tank. Gravel was used as the medium in two of these filters, graded from 1½ to 3 inches, and the fabricated tile medium was used in the third. The tile filter and one of the gravel filters were provided with forced draft mechanisms, and all three were dosed by means of disc distributors. These units were put in operation in August, 1935. In Table IV are given the results obtained from that time.

TABLE IV—LAKE STREET PLANT

Monthly Averages

	*Filter I**			*Filter II***			*Filter III****		
	Infl.	Effl.	Pct. Red	Infl.	Effl.	Pct. Red	Infl.	Effl.	Pct. Red
September ...	208	41	80.5	218	45	79.4	218	62	71.6
October	189	33	82.5	197	25	87.8	145	36	75.2
November ...	146	38	74.0	150	35	76.8	150	37	75.3
December	323	70	78.3	310	72	76.5	291	57	80.5
January	396	88	77.0	387	96	75.0	423	61	85.5
February	...	..	...	446	160	64.3	452	76	84.1
March	523	90	82.7	508	75	85.6	496	72	85.3
May	330	63	80 9	334	60	85.0	334	63	82.2
June	366	59	85.2	366	65	81.7	375	48	87.0

*Gravel plus forced draft. **Tile plus forced draft.
***Gravel without forced draft.

Filters I and II, which have forced draft, gave better reductions than Filter III until the end of October. In fact, at that time, Filter III showed distinct signs of ponding because of poor ventilation. After November 1, the temperature of the air dropped below that of the liquid and Filter III began to improve. During November and December, Filters I and II dropped off in efficiency, indicating that forced draft was then injurious. The cold air forced through the beds must have cooled them too much. The effect on II (the tile bed) was greater than on I, probably because considerably more air was forced through this bed than through the gravel bed. In fact, in the tile bed, even after forced draft was discontinued, the temperature differential created an excessive flow of air. Therefore, in the latter part of February we blocked off part of the air vent, and this had a decidedly beneficial effect.

In the late spring and summer of 1935 there was no evidence of mold growth at the Oak street plant. Several factors may have been responsible for its disappearance. Because of the rise in the temperature of the sewage, bacteria may have been able to multiply faster than the molds, and thus prevent their growth. The character of the sewage may have changed as a result of changes in the operation of the industrial plant. The larger amount of soil carried by the sewage in the spring may have furnished an inoculum of an organism which parasitizes mold. It is known that certain organisms, particularly the Myxobacteria, do parasitize higher fungi, and if these organisms become established in the filter, they could prevent the growth of mold. If the disappearance of the mold was due to either of the first two factors, there is not much that can be done by way of prevention. If the third factor was responsible, one might control the difficulty by deliberate inoculation of the filter. In the fall of 1935, there were indications that mold growth was beginning in the new plant. We inoculated the sewage with soil, putting a pail of soil per day in the primary settling tank, and since then have had no further difficulty. We are not certain the soil inoculation was the controlling factor, but the evidence at least points toward that.

Our experience with the new experimental plant indicates that high dosage is practical. Although we do get somewhat lower reductions in the winter than in the summer; however, winter operation gives reductions of 80 per cent or above.

Creamery Waste Studies

After starting these experiments, the State Board of Health offered us the use of one of their experimental plants on which to test the high dosage principle on creamery waste. The State Board had built a small experimental trickling filter at a creamery near Minneapolis, 10 x 10 x 10 ft. deep, made up of three sections, containing gravel, trap rock, and lime rock respectively. This particular creamery produced a very strong waste, the B.O.D. running from 4,000 to 8,000. At periods of maximum production, there were about 10,000 gallons of waste per day. The State Board had found that the bed would function efficiently when dosed at a rate of from ½ to 1 million gallons per acre per day. The experimental filter could thus treat about 1/10th of the waste from the creamery.

Before starting our work we made some changes, installing a disc distributor in place of the tip-trough, replacing the lime rock with the fabricated tile medium, and providing a storage tank so that the dosage would be continuous for 24 hours rather than just during those hours when the creamery was in operation. For this purpose, we made use of an old septic tank, large enough to give a 4-day storage. The souring which takes place in this tank precipitates the casein, while the fats tend to rise to the surface. To prevent septic action at the start, sulphuric acid was added to the waste so as to reduce the pH in the tank to about 4.5. After two weeks, sufficient fermentation of lactic acid had taken place to maintain this pH, and no further additions of acid were necessary. Because of the high strength of the waste, we found it necessary to put it through the filter more than once, in order to reduce its strength to that of ordinary city sewage so that it could be successfully handled by the municipal plant. It was our aim, therefore, to reduce the strength to a B.O.D. of about 200. We constructed a resettling tank large enough for a 2-hr. detention, with a flow of 30 gals. per minute. The waste was pumped from the storage tank into this resettling tank at the rate of 7 gallons per minute; 23 gallons per minute of effluent from the filter flows into the resettling tank also, thus giving a total flow into the tank of 30 gallons per minute. Thirty gallons per minute are pumped into a small dosing tank above the filter, from which it flows to the disc. A 4-ft. head in the dosing tank provides good distribution over a circle 10 ft. in diameter. This rate gives a dosage of about 25 million gallons per acre per day. The 24-hr. operation enables the plant to take care of all the waste coming daily from the creamery. The plant has now been in operation for about a year, with results as indicated by the typical data in Table V.

TABLE V—LAKEVILLE CREAMERY

5-day B.O.D. Values

	June	*July*		*August*			*Sept.**
	25	*10*	*24*	*9*	*16*	*30*	*19*
Plant influent...	3525	3450	2700	2865	2410	2580	2480
Stor'ge tank effl.	2082	2600	2170	1260	1850	1624	1350
Filter influent ..	912	1275	1350	428	740	477	396
Filter effluent...	403	634	750	106	123	132	62
Filter, % reduct.	88	82	72	96	95	95	97
City plant, infl...	79	....	....	....	....	105	....
City plant, effl...	24	....	....	....	....	8	....
Overall reduct., %	99	....	....	....	....	99	....

Effect of Different Media

Date	Influent	Effluent *Gravel*	*Trap*	*Clay*
August 16	793	276	328	183
August 30	515	114	139	70

*Minnesota State Department of Health.

During the time that the Lakeville creamery plant has been in operation, there have been no marked odors from the storage tank. The high acidity apparently has stopped septic action. The tank has never been cleaned, although I believe it advisable to clean tanks of this sort twice a year. The particular tank at this plant is perhaps larger than is actually needed, but it is our belief that plants using this principle should have storage space for at least two days' waste. It will be noted in the table that the overall reduction has been calculated from the raw waste of the creamery to the effluent of the city plant. This is justified because 90 per cent of the waste entering the municipal plant is creamery waste, that is pretreated at the creamery plant. The municipal treatment plant consists of an Imhoff tank and a trickling filter.

Chicago Experiments

The Sanitary District of Chicago has constructed an experimental plant using the high dosage principle on domestic waste. The filter is 20 ft. in diameter, filled with limestone ranging in size from 1½ to 3 inches, to a depth of 8 ft. It is dosed by means of a rotary distributor at the rate of 20 million gallons per acre per day. Because the raw waste at Chicago is much weaker than ordinary domestic waste, this plant does not give as high percentage reduction through the filter as we have obtained; nevertheless, the results have, in general, confirmed our observations.

Summary

In summary, we would draw the following conclusions from our observations.

1. Rest periods are not essential for the operation of properly designed trickling filters. Short rest periods will probably do no harm, but long rests are definitely injurious to the performance of the unit.
2. The loading of trickling filters can be increased from the conventional 2 million to 20 million gallons per acre day when properly applied.
3. A dosage of from 7 to 10 million gallons per acre per day is not to be recommended because of dangers of ponding.
4. By dosing the beds continuously, fly nuisance can be eliminated.
5. A fabricated tile filter medium is recommended for strong wastes as an additional safeguard against ponding.
6. The growth of Fusariea can be controlled by soil inoculation.
7. Forced draft is essential during those seasons of the year when the temperatures of the air and water are about equal.

Acknowledgment: This paper, prepared for WATER WORKS AND SEWERAGE, was presented by the author before the Pennsylvania Sewage Works Association at State College, Pa., June 25, 1936.

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Design of Aeration Tanks for the Activated Sludge Process

The following notes have been drawn from a paper on "The Design of Aeration Tanks for the Activated Sludge Process" which was presented before the American Society of Civil Engineers by S. W. Freese of Hawley, Freese and Nichols, Engineers of Fort Worth, Texas.

Although the capacity of aeration units, the quantity of returned sludge and aeration period is governed by the strength of sewage to be dealt with, data from a number of plants indicate the air requirement in spiral flow aerators to be approximately 0.45 cu. ft. per gallon of sewage for every 100 p.p.m. of 5 day B.O.D. removed by the plant between the screens and the final effluent weirs. The spiral flow tank, with air diffusion, performs more economically than does the "ridge and furrow" design of tank. Still more economical in air required and overall power consumption is the combination of spiral flow air diffusion will mechanical paddles, providing the essential agitation (turnover) of the sewage-sludge mixture.

Concerning the width to depth dimensions of aeration tanks—designs having a width twice the depth has been found more economical and also sound practice at Chicago.

As to the value of preliminary sedimentation of sewage; data from a number of plants indicate that the quantity of air required for *complete* treatment seems to bear but little relationship to the degree of preliminary sedimentation given the sewage. In fact, plants providing for no primary treatment of the crude sewage, other than screening, have seemingly required no more air per unit of overall B.O.D. removal than have those plants where effective preliminary sedimentation has been provided. (This observation is especially interesting and possibly indicative of the future trend in omitting costly primary settling tanks from activated sludge plants to advantage in more than one direction—not the least being the passage of waste activated sludge through these units to add a most undesirable load the aeration process, at times to a disastrous degree.—Ed.)

The porosity of diffusor plates does not seem to have the meaning earlier assumed, when fine-grained plates to produce fine bubble size were assumed desirable and specified. Base on more recent experience, coarse grained plates with permeability ratings between 35 and 45 may safely be employed with resultant savings in operation as well as maintenance costs. These coarser grained plates, in fact, produce bubble sizes little if any larger than the easily clogging fine grained plates with porosity ratings of 15 or thereabouts. In placing diffuser plates the use of corrugated rubber gaskets and clips or plate holders seemed fair to displace the older method of cement grouting the plates in place—a practice which prevented the removal of plates intact and makes removal for servicing or cleaning difficult, hazardous and costly.

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N. Y. Section Meeting Dates Advanced One Week

The meeting of the New York Section of A.W.W.A., originally scheduled for October 22nd and 23rd at Saratoga Springs, N. Y. (Hotel Gideon Putman), and so listed under "Meetings Scheduled" in our August issue, has been advanced one week. The new dates announced by Secretary R. K. Blanchard are October 15th and 16th.

A. W. W. A.'S CENTRAL STATES SECTION HOLDS RECORD MEETING

IN CLEVELAND, OHIO, August 19, 20, and 21, American Water Works Association's much-alive Central States Section held by all odds its most successful meeting. The record attendance and official registration of 239 compares with approximately 180 for the highly successful 1935 meeting in Pittsburgh.

More important than mere numbers was the quality of registration, which revealed by far the highest percentage of operating men in attendance that has been recorded in recent years for the Central States Section.

Noteworthy was the quality of program, improved attendance of the technical sessions, non-elaborate but adequate entertainment. And, with it all, the reasonable and sensible registration fee of $2.00 covered a luncheon, the well-served and delectable Hotel Cleveland dinner, floor-show and dancing.

On the second day members and guests were taken on an inspection trip of Cleveland's Baldwin Filtration Plant, where as host the Department of Water Supply served a toothsome buffet luncheon in the filter operating gallery. Simultaneously, the ladies attending were given a luncheon in the gardens of Cleveland's Museum of Art, and thereafter a tour.

President Hurlbut Attends

From Los Angeles came A. W. W. A.'s President, W. W. Hurlbut, to attend sessions, hold important committee meetings and briefly address the section during the annual dinner. He commented on the recent membership growth enjoyed by A. W. W. A.—now, but 91 under the all-time peak membership attained in 1929. He stressed the undebatable fact that every water works, small or large, privately or municipally owned, should support A. W. W. A., and thereby benefit accordingly, by maintaining therein a Corporate membership. (NOTE: Each Corporate Member has the privilege of naming one individual as an Active (voting) Member. The name of this representative becomes listed in the published roster of members of the Association—he becomes a full member. This, in addition to the customary listing of the company or water department under Corporate membership.—ED.)

President Hurlbut, who later visited A. W. W. A. headquarters in New York, said that he had come far to attend this splendid sectional meeting. He remarked that it was indicative of the current progress and expansion in A. W. W. A., that seemed to warrant predictions of an excellent future ahead for the Association.

Jim S. Dunwoody, Gen. Supt., Erie, Pa. For President of A. W. W. A. His Section Is Boosting Him.

W. W. Hurlbut, Pres. A. W. W. A. From Los Angeles He Came to Plead for More Corporate Members.

"Local Talent"

Sleight of hand tricks by the Section's able and genial Secretary, Lloyd Nelson, in which at one stage President Hurlbut was victimized, added a tint of enjoyable "local talent" to the entertainment. Following this, Professor Lewis Carpenter, A. W. W. A. Director representing the Section, showed several reels of films in color which he had taken of scenery and persons on the A. W. W. A. Excursion to the Los Angeles Convention in June; likewise, during the convention and returning via the Canadian Rockies. In vivid coloring, some of the scenic effects, with billowing clouds above, seemed to surpass even their actual beauty. Say we, Hollywood's camera aces have nothing on A. W. W. A.'s Carpenter.

On the opening evening the featured attraction was the instructive and beautiful Great Lakes Exposition, located but a stone-throw from headquarters hotel on Cleveland's lake shore.

Resolutions

Amongst the resolutions passed by the Section was one unqualifiedly approving of the actions taken by A. W. W. A.'s General Policy Committee and endorsing its recent reorganization procedure and proposed program of betterments for the Association. Another resolution called for support of President Hurlbut in his urge for an expanded Corporate Membership and a resolve to participate in the drive for such. The death during the past year of a member, E. G. Bradbury, Cons. Engr., of Columbus, Ohio, was lamented in the form of a resolution.

Especial appreciation was voted Norman J. Howard, of Toronto, Ont.—guest speaker—for his very splendid paper; and, to W. C. Lawrence, Superintendent, Baldwin Filters, for his work as Chairman of the Committee on Local Arrangements.

Officers Elected

For the Nominating Committee, Hayes R. Kuhns (Chairman) reported the following choices to fill offices for the ensuing year:

Chairman—Roberts Hurlbut, Sr. Chemist, Detroit, Mich.

W. W. Moorehouse, Supt. Water Works & Sewerage, Dayton, Ohio, Retiring Chairman.

Roberts Hulbert, Senior Chemist, Water Department, Detroit, Mich., Incoming Chairman.

Cleveland's J. W. Ellms, Pioneered Water Purification with Fuller, Weston, et al., at Louisville and Cincinnati.

Cleveland's George Gascoigne, Consulting Engr. (Pres. Amer. Society Municipal Engrs.). Has Many Plants to His Credit.

Vice Chairman—E. C. Trax, Sup't Filtration, McKeesport, Pa.
Sec'y-Treas.—L. C. Nelson, U. S. Cast Iron Pipe Co., Pittsburgh, Pa.
Trustee*—E. A. Johnson, Pittsburgh Equitable Meter Co., Pittsburgh, Pa.
Director**—L. V. Carpenter, New York University, New York City.

Technical Sessions

CHAIRMAN W. W. MOOREHOUSE, Presiding
(Dayton, Ohio)

"Cleveland's Water Works System," by Frank O. Wallene, Director of Utilities, Cleveland, Ohio.

Mr. Wallene briefly traced the history of Cleveland's Water Works since Cleveland became a city, just 100 years ago. Interestingly, Cleveland never was served by a privately owned system, the movement for a municipally owned system being started in 1851 and water from Lake Erie pumped into the public system in 1856. In 1911 chlorination of the supply was begun and in 1917 the first (Division Ave.) filtration plant was completed.

Today, Cleveland's system serves 1,200,000 people filtered water through 2,712 miles of mains and 165,000 metered connections; boasts 100 per cent meterization other than to municipal properties where $275,000 worth of water annually is not collected for. Under way, said Mr. Wallene, was a movement toward correction of this free water evil. The Water Department averages 1,367 employees; payroll roughly $1,800,000; gross billing (quarterly) for sales of water averages $5,200,000 annually. A real problem in recent years has been the accumulating delinquent accounts, now totaling $1,700,000, which has necessitated curtailment of leniency and stricter shut-off practice.

Cleveland has two intake channels and two modern filtration plants (Division and Baldwin) with combined capacity of 315 M.G.D.; three major pumping stations, 310 M.G.D. capacity; the largest concrete covered reservoir in the world, with 135,800,000 gal. capacity. There are five pure water reservoirs and numerous small booster pump stations. In the grid-iron distribution system (2,712 miles of mains) no pipe smaller than 6 inch has been laid during the past 15 years, the present idea being to use nothing less than 8-inch except for runs of less than 600 feet. Existing mains are practically all cast-iron (98.8%), but since 1923 the practice had been to utilize steel pipe for mains 36-inch and larger. Lately, electric-welded steel pipe had been employed, with Dresser couplings, for diameters down to 30 inch. Fire hydrants, in general, were 300 ft. apart; valves 500 to 1000 feet apart on the larger and at all principal intersections on the grid system. In recent years copper tubing had superseded lead pipe for services, with stop cocks located one foot inside the curb line on domestic services and valves 2 ft. from main on the larger services.

Mr. Wallene said that Cleveland's early studies had justified the ammonia-chlorine treatment for taste control and its value in maintaining sterile conditions within the mains throughout the system. The process had been successfully employed since 1929 at a cost of but 35 cents per million for both chlorine and ammonia. The purification plants were kept modern and efficient through laboratory control and by operating personnel of the highest technical calibre.

In the ensuing discussion, DANIEL C. GROBBEL, Engineer and Secretary, Detroit's Water Commission, called attention to the value of recorded history of the accomplishments of Water Departments and its use to acquaint municipal officials and the public of such accomplishments. Local universities or colleges could be gotten interested in assembling recorded information and preparing such a historical review. Such a program was now under way in Detroit.

The chief discussion of Mr. Wallene's paper centered on the matter of free water to public properties and the large figure representing uncollected water charges.

W. W. MOOREHOUSE (Dayton, O.) said that Ohio public schools, through a recent court decision, could be forced to pay for water supplied them. In Dayton, delinquent water bills, for the most part, were obtainable from Federal relief agencies.

D. C. GROBBEL said that delinquent water bills in Detroit reached a high of $1,500,000 at one time. With 75,000 families on relief Federal agencies are paying their current water bills, nothing being allowed, however, on the accumulated delinquencies. To force landlords to pay, attempts are made to secure checks issued by Federal relief agencies to cover rent and, where successful, these are held to force payment by the property owner before release of checks. Since water works employees were forced to pay Federal income tax, it was his opinion that pressure should be brought to force Federal agencies to pay the water bills of its charges. (Seemingly, a most reasonable and justified thought. —ED.)

W. W. BRUSH said that in emergencies relief agencies would pay bills. Such an "emergency" might easily be established by a water shut-off.

Officers

Ed. Trax, Supt. Filtration, McKeesport, Pa., Vice Chairman; Floyd Nelson, Sales Engr., U. S. Pipe, Pittsburgh, Sec'y-Treas.; L. V. Carpenter, Professor N. Y. University, New York City, Director.

*Elected for 3-year term. Previously serving out the term of the late George C. Keefer.
**Prof. Carpenter, now a non-resident, has been asked to complete his term as A. W. W. A. Director representing the Section.

Norman J. Howard Director, Water Purification, Toronto, Ont.

F. H. Waring, Chief Engineer, Ohio Dept. of Health

B. J. LECHMER, Secretary, Erie Water Commission, said that properties in Pennsylvania were subject to lien if unpaid water bills existed. Therefore, in event of sale, before property record is clear delinquent water bills must be paid—and, were.

"Observations in the Toronto Filter Plant Laboratories During the Past 25 Years," by NORMAN J. HOWARD, Director of Water Purification, Toronto, Ont.

Mr. Howard's interestingly presented paper covered the high-lights of laboratory experiences in water purification control since establishment of the laboratories at Toronto's filter plant in 1911. In this he recounted the several valuable studies and contributions made in connection with improved bacteriological procedures and media; taste and odor control studies, involving much laboratory research and plant trials, which led to the adoption of superchlorination and dechlorination with sulphur-dioxide as the most practical method for Toronto conditions wherein adequately long contact of chlorine with the filtered water is available before dechlorination; studies of filter sands, which led to the conclusion that sand coarser than 0.30 mm. size (viz. 0.56 mm.) was overall preferable for Toronto's rapid sand filters; coagulation studies, with reference to pH effects and passage of unprecipitated alumina through filters, proving also its lack of sanitary significance or corrosive properties, but merely economic waste; the part played by orientation in the adsorptive properties of solids and filter media; errors involved when making residual chlorine tests in direct sunlight; the failure of high chlorine dosages to reduce the pH of potable waters; and, several lesser studies resulting in operating betterments.

Mr. Howard felt that the most important operating contribution made in the Toronto laboratories constituted the perfection and establishment of the super and dechlorination process. Especially significant had been the studies indicative that end-products from a variety of decomposing organic materials (sewage included) were productive of chlor-phenolic tastes similar to those from chemically produced phenolic wastes, but, that all could be destroyed by excess chlorine. The working out of the relationship between time of chlorine contact and the least residual chlorine required was the most important economy measure. It had revealed the efficacy but expense of high residual with short contact vs. the economy of less chlorine excess with contacts of 2 hours and better. Further, investigating the effect of pH on taste production and taste elimination—a low pH was found less productive of tastes than a pH on the alkaline side—unless it be extremely alkaline.

The once frowned upon and discontinued pre-chlorination had been returned to its justified place at Toronto in 1921. The resultant safety benefits and economies had been markedly demonstrated through a coagulant saving amounting to $34,000 annually—sufficient each year to maintain the laboratory service for two years. Thus, commented Mr. Howard, can laboratory control and research bring better water, favorable publicity, and economic benefits, to cities which employ it. If his paper proved stimulating, that was its chief excuse for existence.

W. W. BRUSH, Editor, *"Water Works Engineering,"* in complimenting Mr. Howard and the Toronto laboratory staff, said that in his opinion A.W.W.A. should officially sponsor research in water treatment as a measure of producing valuable information and stimulating membership.

M. M. BRAIDECH, Prin. Chemist, Baldwin Filters, added his compliments and subscribed to the Brush suggestion. Research in water works operation, he said, had two costs. The first, that of doing it, seemed burdensome and expensive perhaps—but, the further analysis revealed a greater cost, that of *not* doing any research.

W. C. LAWRENCE, Supt., Baldwin Filters, cited instances to show that the return on the investment made in laboratory and experimental plant studies at Cleveland had richly justified the expense.

"Effect of Mine Drainage on Rivers and Water Supplies in West Virginia," by PROFESSOR W. W. HODGE, University of West Virginia, Morgantown, W. Va.

Professor Hodge, in reviewing the extent of damage caused by acid drainage from abandoned and working coal mines entering water supply streams, said that the most affected cities in W. Va. were Clarksburg, Morgantown and Fairmont. Iron, hardness and acidity, with marked variations as to degree, had made water purification difficult and costly and resulted in an inferior quality of treated water. Estimates of cost to municipalities in the Ohio River basin, for extra treatment required, considerably exceeded one million dollars annually. To correct the condition a Federal financed program of air sealing abandoned mines, as the most practical method, had been under way during the past few years in 10 states. The work in 21 W. Va. counties had been effective to July 1, 1936, in closures to 345 of the 427 mines to be sealed. The cost had been but $276,000. Streams as acid as pH 3.0 had been returned to the alkaline side for the majority of the time, if not continuously. Formerly, 848,000 lbs. or more of sulphuric acid entering streams in the form of mine drainage daily had been cut to approximately 188,000 lbs. per day. Citing a concrete case of the C. & O. Railway supply at Whitman Junction, Prof. Hodge presented data supplied by the company showing reduc-

Trustees

T. L. Young, Mgr. So. Side Water Co., Chester, W. Va.; E. A. Johnson, Sales Mgr., Pittsburgh Equitable Meter Co., Pittsburgh, Pa.; W. R. La Due, Supt. Water Works, Akron, Ohio.

H. E. Moses, Asst. Chief Engr., Penna. Dept. of Health; E. S. Tisdale, Chief Engr., W. Va. Dept of Health; W. W. Hodge, Professor of C E., Univ. of W. Va.

tion of acidity of 127 p.p.m. (5 yr. avg.) to 5 p.p.m., or less, as the monthly average since the sealing program. Chemical costs alone had been reduced $25,000 annually at the C. & O. treatment plant.

R. C. BARDWELL, Supt., Water Supply, C. & O. Railway System, Richmond, Va., verified the figures presented by Prof. Hodge and the importance of the mine sealing program to industry and municipality. He wished to compliment Mr. Tisdale, State Sanitary Engineer, and his staff on the accomplishments in West Virginia.

E. S. TISDALE, Chief Engineer, W. Va. State Department of Health, felt that the Ohio River basin program was another concrete demonstration of the value of joint programs undertaken by state agencies on intrastate streams. The first attempt had been that successfully initiated by the late Dr. Monger, Commissioner of Health of Ohio, when in 1923 abatement of phenol pollution was taken up by the then organized Ohio River Board comprising health department personnel from the several states drained by the Ohio and tributaries.

F. H. WARING, Chief Engr., Ohio State Department of Health, explained the methods in air sealing of coal mine entries and vents—the seal being basically a liquid trap allowing water to flow out of the mine, but no passage in of air. In Ohio 1,000 closures per month were being made, with the program only 40 per cent completed and $500,000 of Federal-aid money spent to date to eliminate 200,000 lbs., of acid production daily. He related some interesting experiences, amongst which was the strategic move of hiring the "King of Bootleggers" to arbitrate with coal mining boot-leggers hostile to the mine sealing work, and threatening to workers.

A Modern Repair Shop

"The Proper Maintenance of a Water Distribution System," by JAMES S. DUNWOODY, General Superintendent, Water Department, Erie, Pa.

Concerning water works operations, Mr. Dunwoody said that there was one function in water works management of equal concern to *all* superintendents—Distribution System Maintenance—the topic assigned him. He then commented on the great value of "Knowing your system" by making adequate and careful periodic surveys to disclose the weakest spots. Concerning proper valve maintenance with, at least yearly inspection, he could not say too much. He stressed the importance of using the proper type of a good grade of packing and proper lubrication. In Erie there were 3,907 valves and 1,454 fire hydrants to be maintained.

After briefly describing Erie's distribution system, supplying 121,000 water users (25,900 services) and divided into low and high and booster service districts served by 268 miles of cast-iron mains, Mr. Dunwoody described in some detail the recently modernized, enlarged and strategically located Maintenance Headquarters and Repair Shops recently completed in Erie. On the same property (and considered an important feature) was a foreman's apartment. The building, of steel and concrete construction, had been designed for effective lighting of shops. Space had been provided for storage of a car of cement and car of joint-compound, car of fuel oil and gasoline. A rail siding had been run through the yard and overhead crane-way provided to cover the entire yard. One room (54 x 67 feet) was devoted solely to a shop for automotive equipment repair and maintenance, allowing work on as many as five pieces of equipment at one time, under an A-1 mechanic.

One of the most important features was the design and operation arrangements of the stock-room, the entrance to which was through the office of the Superintendent of Distribution and available only to the stock-clerk. From it, distribution windows were located at three points for convenience of the foreman. Within the store-room (10,450 sq. ft. floor space) could be stored the complete stock of valves and hydrants. (For method of operating and maintaining Erie's stock-room and storage yard, see articles by Mr. Dunwoody in WATER WORKS AND SEWERAGE, Nov. 1933.)

Erie with less than 1,200 meters in use on the larger services required little room for its meter shop, but the shop had been completely re-arranged and modernized. On the second floor were offices of the Superintendent of Distribution, a complete engineer's office, office for stock clerks and men in charge of unit operations.

To provide conveniences, several special features had been adopted. An example was the electric control system for operating important doors from a central point. Any of these may be opened by push buttons at the desk of the clerk in the superintendent's office upon signal from truck drivers or others coming into the yard or shop. The new shop buildings, exclusive of equipment, are evaluated at $145,500; the land (1.04 acres) at $60,800—the total value being $206,300. This, Mr. Dunwoody considers a justified investment when considering the importance of the Maintenance Headquarters to a distribution system valued at almost $6,000,000. In describing the arrangements, a plan was hung before the audience to clarify the speakers description.

"Statistical Reports for Water Works Plants," by A. C. MICHAEL, Asst. Mechanical Engineer for Tests, Department of Water Supply, Detroit, Mich.

Mr. Michael presented a paper impossible to do justice to in abstract form. It discussed the often neglected matter of recorded operating statistics and what may be learned from their analysis and study in bettering performances and economies of pumping and power

R. W. Furman, Commissioner of Water and Supt. Filtration, Toledo, Ohio; D. C. Grabbel, Engr.-Sec'y. Dept. of Water, Detroit, Mich.; E. E. Bankson, Consulting Engr., Chester Engrs., Pittsburgh, Pa.

Lunching at Baldwin

stations. In this he believed the statistical forms now appearing in the Manual of A.W.W.A. needed revision for the sake of clarity, ease of computation, and modernization. On grounds explained, he advocated the setting up of a new arbitrary standard work unit for comparison; namely, that of lifting "1,000,000 gals. through 100 ft." and equivalent to 421.46 water-horsepower hours. More universally understood, however, would be a "water-horsepower" unit. On the blackboard he illustrated calculations and data conversions, necessary to the plan, by utilizing data in typical concrete cases. The presentation was impressive and Mr. Michael's paper warrants study when it appears in the Journal.

Flood Experiences

Flood experiences in Pennsylvania, West Virginia and Ohio constituted a symposium held at Case School of Applied Science in which the effects of the March, 1936, flood had on water works, and the lessons learned therefrom, were presented by three State Sanitary Engineers.

H. E. MOSES, Assistant Chief Engineer of the State Department of Health, in presenting the picture in Pennsylvania, reported that of the 200 municipal and 250 privately owned water works in the state, 106 were to some degree affected and 34 had to shut down. The most prevalent cause had been damaged pump-motors. During and following the flood the Engineering Division of the Health Department had 280 men in the field and remarkable had been the fact that no water borne epidemics had developed and only 4 cases of typhoid had been recorded. Fortunate had been those cities with ample pure water storage and those taking water from upland sources. Amongst the lessons learned were: The great importance of a pure water to a distressed community; the incalculable value of abundant storage; the proper valving of feeder and distribution mains; duplicates of important mains and equipment; the availability of barriers for windows and doors, subject to prompt usage; the desirability of permanent flood control plans and works.

As never before had the invaluable part played by chlorine as the tool of the sanitarian, in routine or emergency, been recognized and demonstrated and the smell or taste of chlorine in temporarily questionable supplies was as comforting to the consumer as reassuring to health officials. Last but not least had the dependability and conscientiousness of many water works operators been proven and to these unsung heroes of the catastrophe he paid especial tribute.

E. S. TISDALE, Chief Engineer, State Department of Health, outlined a few of West Virginia's more serious experiences and acknowledged the invaluable assistance rendered by engineers from the U. S. Public Health Service who had been detailed to the State Department of Health for service during the emergency. He felt that the training received in West Virginia's annual short schools and the effects of the successful operator licensing act, as well as the loyalty of the individuals, were jointly responsible for the adequate functioning of operators where prompt assistance was impossible or inadequate. In many instances chlorination, effectively applied, had saved the day.

He called on A. R. Todd, Wheeling's Superintendent of Filtration, who related experiences in operation, wherein the largest problem had been chlorination capacity when the chlorine demand rose from 2.5 lbs. to 10 lbs. per m.g.; the maintenance of filter output during the run of 10,500 p.p.m. turbidity; housing and feeding operators within the marooned plant; getting rid of dirty wash water. The work of the Wheeling operators and Mr. Todd during the emergency was praised by S. H. Davis, Supt., Benwood, W. Va.

T. L. YOUNG, Supt. of Water at Chester, W. Va., told of his submerged well system and the good fortune of getting their chlorinator installation completed barely in time.

Mr. Tisdale closed by saying that flood experiences had demonstrated the need for more trained sanitary engineers as allies of water departments and agreed with Professor Chas. Gilman Hyde in his urge that every municipality of 50,000 population or more should have a full time trained sanitary engineer in its employ. The value of cool headed qualified or licensed operators had been amply demonstrated as had the value of ample storage of chemicals (chlorine in particular) and machine capacity for feeding.

F. H. WARING, Chief Engineer, State Department of Health, reviewed experiences in Ohio where but a few water works were seriously affected due to preparations made since the 1913 flood to preclude damage to water works within possible reach of flood waters. In Ohio, ample storage had made it possible to sand-bag and abandon plants—notably at Toronto, O. To T. R. Lathrop, Assistant Engineer, Mr. Waring gave credit for handling the more serious problems. Mr. Lathrop later cited an experience of a dependable submerged water system where firemen had dived 6 ft. under water to attach hose lines to hydrants and turn on the water.

Philip Burgess, Consulting Engineer, Columbus, Ohio; R. C. Bardwell, Supt. Water, C. & O. Ry., Richmond, Va.; Geo. E. Barnes, Dept. Head, Case School Sciences, Cleveland, Ohio.

Lunching at Baldwin

What it all meant to the consumer was related by Lloyd Nelson who had shoveled snow into his bath-tub, as the only source of household water, while gasoline trucks brought around safe water for drinking and cooking. Lack of adequate storage had thus caused severe hardships during the 6 day plant shut down.

Value of Hydraulic Models

Working models in the Hydraulic Laboratories of Case School of Applied Science, built under Professor Geo. E. Barnes' direction in the study of structure design for dams, spillways and flood control works, were inspected following a talk on this subject. Professor Barnes employed moving pictures to illustrate the similarity between model operation and functioning of the completed structures designed on the basis of performances of models. In one instance the scour of spillway waters had been broken by utilization of the hydraulic jump which in actual service produces a jump 26 feet high and thought to be the highest in the world. On the Muskingum (Ohio) Watershed Project the model studies in the Cast School laboratories had cost $50,000 covering a 10 month period of 24 hour observations. Considering the economies and assured dependability of structures it was a small part of the cost of the $34,000,000 project. Now to be started immediately were model studies for the Central Nebraska Irrigation Project, involving a storage reservoir of 600 billion gals. capacity.

"The Jewell Sub-Surface Filter Washing System," by R. W. FURMAN, Commissioner of Water, Toledo, Ohio.

Mr. Furman, long time Superintendent of Filtration and recently made Commissioner of Water at Toledo, related observations resulting during an 8 month study of the Jewell Sub-Surface System for raising the capacity of mechanical filters and improved filter washing. He described briefly the design and arrangement of the Toledo experimental installation comprising one filter. (This system is described in an article by C. C. Ley, Supt. of Water, Kenilworth, Ill., in the August, 1936, issue of WATER WORKS AND SEWERAGE. Essentially the same is the Toledo installation, which can not be easily described without illustrations.—ED.)

Mr. Furman explained that the Jewell system made it possible to double the output of a filter to 4 gal./sq. ft./min. by sub-surfacing filtering 2 gal./sq. ft./min. in addition to the accepted surface (downward) rate of 2 gal./sq. ft./min. Then, in washing, the underdrain system supplied the relatively small wash rise of 4 inches per minute as compared to 27 inches through the sub-surface strainers—a total of 31 inches to produce a 21 per cent expansion of the sand bed of 58 mm. effective size sand. The effectiveness and economy of washing had been particularly noteworthy at Toledo where the swirling motion of the sand had scoured old long accumulating incrustations from the sand grains and had thrown the lighter and dirtiest sand to the surface. Sand 16 inches down, formerly coated with 34.5 per cent incrustants, had now but 12.3 per cent. Compared with other units the sub-surface filter had produced bacterial removals in excess of the unequipped units. During a run of deficiently coagulated water the unit had suffered.

Mr. Furman concluded that where additional filter capacity was needed, periodically or seasonally, the sub-surface system seemed a most satisfactory solution. Further, the sub-surface system was superior at all times in economy and efficiency of washing.

Professor Carpenter, in discussion, said that in experimenting with one of the Jewell strainers any desired bed expansion could be obtained with a 30 inch wash rise. He asked for information concerning the cost of equipping the Toledo filters. Mr. Furman replied that all 22 units at Toledo could be equipped for $75,000. To another question—No royalty had been asked by the inventor.

L. I. BIRDSALL, General Chemical Company, Chicago, spoke of the value and growing adaptation of the Baylis Surface Wash System involving jets from a grid of perforated pipes and that the Jewell scheme was along the same line.

"Flows in Settling Basins," by L. S. MORGAN, Penna. Department of Health, Greensburg, Pa., and M. E. FLENTJE, American Water Works and Electric Co., New York City.

(1) (2) (3) (4) (5) (6)

1. *Con. Engr., E. D. Barstow (Akron, Ohio)*; 2. *Supt. C. E. Inman (Warren, Ohio)*; 3. *Supt. A. D. Claggette (Barberton, Ohio)*; 4. *Supt. Filtr., N. J. Humason (Elyria, Ohio)*; 5. *Supt. F. K. Robinson (East Liverpool, Ohio)*; 6. *Supt. J. A. Keils (Mt. Clemens, Mich.)*.

(1) (2) (3) (4) (5) (6)

1. G. W. Knight, Mgr. Natrona Pa. Water Co.; 2. R. R. Weber, Mathieson Alkali, Cincinnati, Ohio; 3. A. B. Miner, Natl. Gypsum Cl., Beaver Falls, Pa.; 4. H. P. Boncher, Dresser Co., Bradford, Pa.; 5. Richard Statham, Industrial Chem. Sales, Cleveland; 6. F. L. Rollins, Chemist, Barberton, Ohio.

Neither author being present, H. E. Moses presented the paper which described tests made with submerged floats at three filter plants to disclose the efficiency (deficiencies) in settling basins. For the purpose, submerged 2 gal. oil can (partly filled with water) were attached to blocks of wood with numbered flags. The depth of float was determined by the length of string from float to block. Graphs and tables revealed the speed of travel of floats submerged at various depths and the short circuiting characteristics of the basins. In one basin at a 2 m.g.d. capacity plant, providing a theoretical detention of 4.5 hrs., the various floats traveled through in periods varying from 0.75 to 4.25 hrs. depending upon the depth of float travel. In another basin with downward inlets there appeared a reverse flow at 4 to 6 ft. depths and a marked deep short-circuiting. At a third plant, with perforated pipe inlet and around-the-end baffle, basin velocities at different depths varied as appreciably and eddy currents were so pronounced as to prevent the floats from traversing the basin in any reasonable time.

The authors concluded that such studies were warranted in connection with most settling basins in order that deficiencies might be detected and corrected by altering inlet design in particular.

L. H. ENSLOW, Editor, WATER WORKS AND SEWERAGE, said that the report of Messrs. Morgan and Flentje constituted ample evidence of the value of flocculators located across the inlet ends of basins. The revolving paddles prevented short-circuiting due to temperature stratification or faulty inlet design. Where installed, basins had been found to be of needlessly large capacity rather than too small as earlier assumed. The explanation was improved coagulation plus creation of a uniform water given a uniform rate of travel across the basin.

L. I. BIRDSALL commented on the value of stilling walls of plank, containing slots or bored holes, installed across the basin to insure uniformity of displacement.

PROFESSOR CARPENTER said that less study and thought had been given sedimentation basin design and behavior than any feature of water treatment plants. In making model studies in connection with basin design or other hydraulic studies, he said that geometric (proportional design) similarity was not sufficient and dynamic effects had to be considered. He referred to the wall effects and the like, which were pronounced when utilizing models in such studies.

Industrial Water Rates

"Rates Charged for Industrial Water in Ohio," by PHILIP BURGESS, Consulting Engineer, Columbus, Ohio.

Mr. Burgess, in dealing with the always interesting matter of establishing rates to encourage large industrial consumers to buy water from the municipal system, cited the Youngstown, Ohio, case to bring out some of the questions which were decided or raised by the Court in concluding that Youngstown's proposed industrial rates were discriminatory. Amongst these were the following: A rate based solely on added "out-of-pocket-costs" to the city for additional water put through the system was held unfair to consumers paying rates designed to support the entire system—except that the element of public fire protection expense and high-service pumping costs might be deducted. (In Ohio no support is derived from the tax fund for fire protection and hydrant rental et al. is included in water rates. Further, in Ohio, municipal water works can not make profits for other municipal use and are subject to all restrictions placed on privately owned systems, and that rates can not be made based upon "expediency" alone.)

In respect to the latter, Mr. Burgess pointed out the frequent failure to appreciate this point of law when a surplus of supply is sold to otherwise non-users at reduced rates in order to boost gross income. Further, he called attention to the recommendations of the two leading American water works associations that sliding scale rates should never contain a minimum rate less than 25 per cent of the maximum rate scheduled. A study of rate schedules of 30 of the larger cities shows that all but two (Cambridge, Mass., and Minneapolis, Minn.) have sliding scale rates—the average spread between minimum and maximum being 1 to 2.7 with three municipal plants exceeding the recommended maximum spread of 1 to 4. (In the Youngstown case the industrial rate at cost, was but 10 per cent of the maximum domestic rate and held discriminatory. Further, the profit from the domestic rate was found to be 300 per cent.)

Mr. Burgess closed by listing the following salient points in legal rate fixing for large consumers in Ohio.

1. In computing the cost of industrial water, it is not proper to include the costs of services or equipment which do not benefit the class of customer in question.
2. In computing industrial or any other rates, the cost of service *as a whole* must be taken into account—not merely those costs commonly known as actual "out-of-pocket-costs."
3. That "expediency" will be illegal whenever discrimination can be shown—the dividing line being frequently a narrow one.
4. That Ohio water works, municipally operated, can not make a profit and must conform to rules and regulations laid down for rate making by private companies.

ARE YOU PROGRESSING— OR ARE YOU WORTH ONLY FOUR DOLLARS A DAY?

IT was fifty-five years ago that a group of progressive and energetic water works men, representing many cities and towns in New England, met in Boston and formulated plans that created the New England Water Works Association.

Roger W. Esty, Supt. Water, Danvers, Mass.

It organized with twenty-eight members, and John H. Lyons of Salem, Massachusetts served as its first President.

Two meetings were held yearly for some time, and later a more extensive program was encouraged. Now the association, having grown to a membership of 800, holds several meetings during the year.

This organization is comprised of many of the outstanding water works men and engineers in the profession, and its representation is international in scope.

It has withstood the past years of depression, and its membership and financial structure has weathered the times.

It should be the duty of every water works man to belong to some water works organization to obtain all the knowledge possible as to how to improve his plant, both physically and financially.

Every Mayor or Board of Water Commissioners should provide expense money and insist that the Superintendent of Water Works should attend all of the activities of such an organization, and fraternize with fellow superintendents and others, to learn of the latest methods, materials, and equipment being used to better the water supply and produce economical results.

The expense involved is insignificant compared to the knowledge obtained and the friends that are made.

Younger men of the various water departments should be encouraged by their superiors to attend the activities of such an organization and various water works magazines and literature should be provided for reading and study in their spare moments.

Few water works men realize or appreciate what an important cog they are in the every-day life of the community or their true worth.

The health of every man, woman and child, the protection of all of their property is in the hands of the Water Works Superintendent and those who come under him in an operating capacity.

What would happen to the responsible head if the water became polluted and an epidemic swept through the community, or homes or places of business should be wiped out by a fire, due to a lapse of safety or inadequacy of the supply of water?

In the final analysis the local manager of the water works is, perhaps, the most important individual in the community, and is probably given the least consideration of any of the officials who serve the public.

His remuneration, in most instances, may be construed as an insult to his ability and bears no relation whatever to the time and thought that he puts into his work. It has been shown by recently compiled statistics that the average pay of a Water Works Superintendent is approximately $4.00 per day. If he worked no more than eight hours each day it would be just 50 cents per hour—with no recognition for the responsibility he bears. Think of it!

The New England Water Works Association invites all water works men to become members of its organization.

The technical and practical programs together with the entertainment and social activities are worth many times the expense necessary to attend.

The Journal creates a reference library that is invaluable.

You owe it not only to yourself, but to the community you serve to become a member of one of the two leading water works associations—if not both.

Roger W. Esty

PRESIDENT,
NEW ENGLAND WATER WORKS ASSOCIATION.

VENTURI FLUMES FOR SEWERS

By H. K. PALMER*
Los Angeles, California

Always a problem, is the measurement and recording of flows in sewers. Herewith is described a method successfully utilized in the Los Angeles County system since 1933.

THE flow of sewage is more difficult to measure than water because the solids tend to settle as soon as the velocity is retarded below about one foot per second, and in so doing change the characteristics of the meter. Also, because it is usually carried in pipes or narrow conduits buried deep in the ground where access is difficult and the special structures required are expensive.

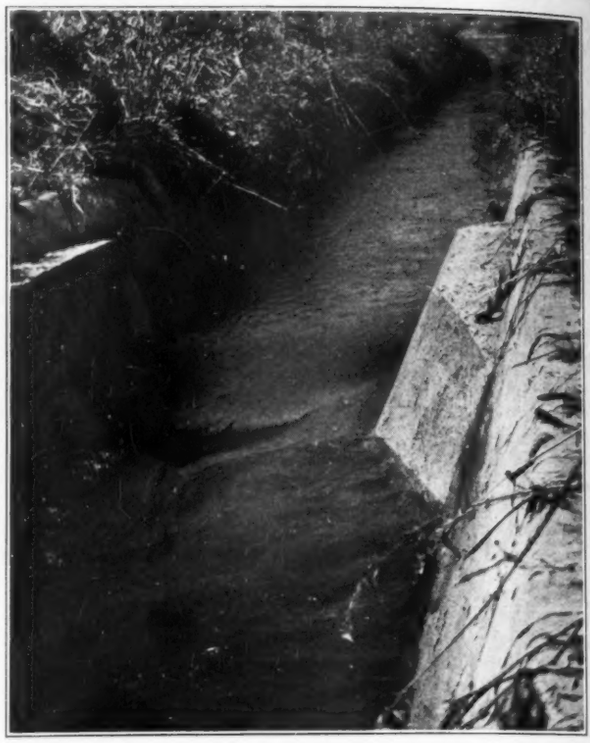
Weirs, generally used as measuring devices, are open to the objection that aside from being rendered inaccurate by the solids settling behind them, if properly installed to give good results, can not handle more than about forty per cent of the maximum capacity of the sewer.

The Parshall meter (flume) is an excellent device for irrigation canals, but it has drawbacks when applied to sewers, one being the rectangular shape of the throat which does not fit the round pipe, so that a meter small enough to measure the small flows will not be sufficient for the storm flows. Since metering is secondary to the ability to discharge the full designed capacity of the sewer, this may be quite serious. If a Parshall meter is installed when the sewer is first built, the required three-inch drop in the invert can be provided, but if it is to be placed in a constructed sewer the only recourse is to raise the throat and transition section. Therewith, is required a special structure because the ordinary manhole is too small. Neither is the use of the float well in a sewer advisable, because solids collect and decompose in it unless a stream of fresh water is available to maintain a small continuous flow from the well to the meter.

The Venturi Sewer Flume

With the Venturi type of flume to be described, a float is set in the channel above the flume, a method which is not feasible with the Parshall meter because the point of measurement is in a contracting channel and the water surface is not level.

The photograph showing a Venturi flume built in an irrigation ditch (it being impossible to get a similar photograph in a sewer), illustrates the manner in which the water flows when the flume is properly designed and built. For pipes, it has been found that the best shape is trapezoidal with the sides sloping, 2 vertical to 1 horizontal, and the length of the throat should be about the diameter of the pipe. In the transition sections a longitudinal batter of 1 transverse to 3 longitudinal seems to be very satisfactory, though theoretically it would be better if flatter. The same transition is used at both ends, and on the bottom section as well as the sides. No change of grade being required, it can be built in a constructed sewer by merely stopping the flow long enough to place the forms and pour quick-setting concrete. In some cases it has been poured without stopping the sewage flow. If the flow is too great to permit placing forms and pouring concrete a pre-cast slab can be placed on the bottoms only, and it will give fair results if the variation in flow is not too great.



The Venturi Type Flume As It Is Constructed in a Sewer. Photographed in an Open Channel to Picture the Behavior of Flow Through a Properly Designed Unit

It was formerly thought that with a Venturi flume it was necessary to measure the depth in both the channel above and in the throat, but it has been found that if the throat is properly proportioned to the size and grade of the pipe, a single depth measurement in the channel above the transition section is sufficient.

Venturi meters and Venturi flumes both depend upon the Bernoulli principle, that the energy in each pound of water flowing through them is equal to the pressure plus the velocity head, and is constant except for friction and eddy losses. For a well-constructed flume of the size used in the ordinary sewer, the energy head can be considered a constant within the limits of accuracy of the recording instrument. The contracting transition section of either the Venturi meter or the Venturi flume causes an increase in the velocity and the corresponding velocity head increases with the square of the velocity. Since the energy is constant, there must be a corresponding decrease in the pressure. In the Venturi meter the cross sections are definite because the pipe and throat are full, but in the flume the pressure depends upon the depth which must vary with the cross section. Therefore, in the throat the water surface will be lower than in the conduit above, as is shown in the photograph.

Relationships of Velocity and Energy

As an illustration of the effect of this principle, suppose that one cubic foot per second were to flow through a rectangular flume one foot wide at various depths.

*Chief Draftsman, Los Angeles County Sanitation Districts.

The effect on the energy head would be shown in the following table:

Depth D (ft.)	Velocity V (ft./sec.)	Velocity Head $V^2/2g$ (ft.)	Energy $D+V^2/2g$ (ft.)	
.6	1.67	.043	.643	
.5	2.00	.062	.562	
.4	2.50	.097	.497	
.325	3.08	.147	.472	
.314	3.18	.173	.471	Critical
.300	3.33	.173	4.73	
.25	4.00	.248	.498	
.20	5.00	.388	.588	

It will be noted that as the depth decreases from .6 ft. to .314 ft. the energy head decreases from .643 ft. to .471 ft. but a further decrease in the depth increases the energy head. The depth .314 ft. is what is known as the critical depth for one cubic foot of water per second in a rectangular channel one foot wide. It is the depth of the water just above the end of such a conduit laid level with a drop at the end, and it is also the theoretical depth over a broad crested weir. Efforts have been made in the past to measure water by measuring its critical depth, but the method was found to be impracticable because of the waves which made it impossible to locate the proper point for measurement. It will be noticed in the table that from depths .325 down to .300 there is a variation of only .002 ft. in the energy head, showing that while the energy is fixed, the depth is not. Obviously the energy should be measured instead of the depth, and that is the basic principle of the Venturi flume described in this paper.

Design of the Venturi Flume

The mathematical analysis and diagram to aid in designing a flume for any condition have been published in the Proceedings of The American Society of Civil Engineers,* so the details will not be repeated here.

There are so many factors affecting the design of a flume, if it is to give fairly accurate results over a large range in flow without affecting the ultimate capacity, that each case should be especially designed, unless a second flume is being installed under conditions nearly identical to those of the first.

At critical velocity the total energy is a minimum and since the total energy cannot increase downstream, it is obvious that in the throat it must be a little higher than in the conduit flow. There is always some loss of energy as the cross section of a stream enlarges and some allowance must be made for this. This allowance should be at least one fourth the difference in the velocity heads in the throat and in the conduit below. To attain this condition the throat should be made sufficiently narrow or the invert of the throat should be raised above the invert of the sewer, or a combination of the two should be used.

Having selected a throat and computed the energy heads in the throat and in the conduit above, for various quantities of water, it is only necessary to subtract the corresponding velocity heads in the conduit above to find the depths and to draw a rating curve through these points giving the quantity for any observed depth.

A simple way of expressing the principle upon which the design is based is to say that the elevation of the water surface at the point of measurement is equal to

*"Adaptation of Venturi Flumes to Flow Measurements in Conduits," by Harold K. Palmer and Fred D. Bowlus, Proc. Am. Soc. C. E., Sept., 1935, with comments in Nov., 1935; February, March, April and May, 1936."

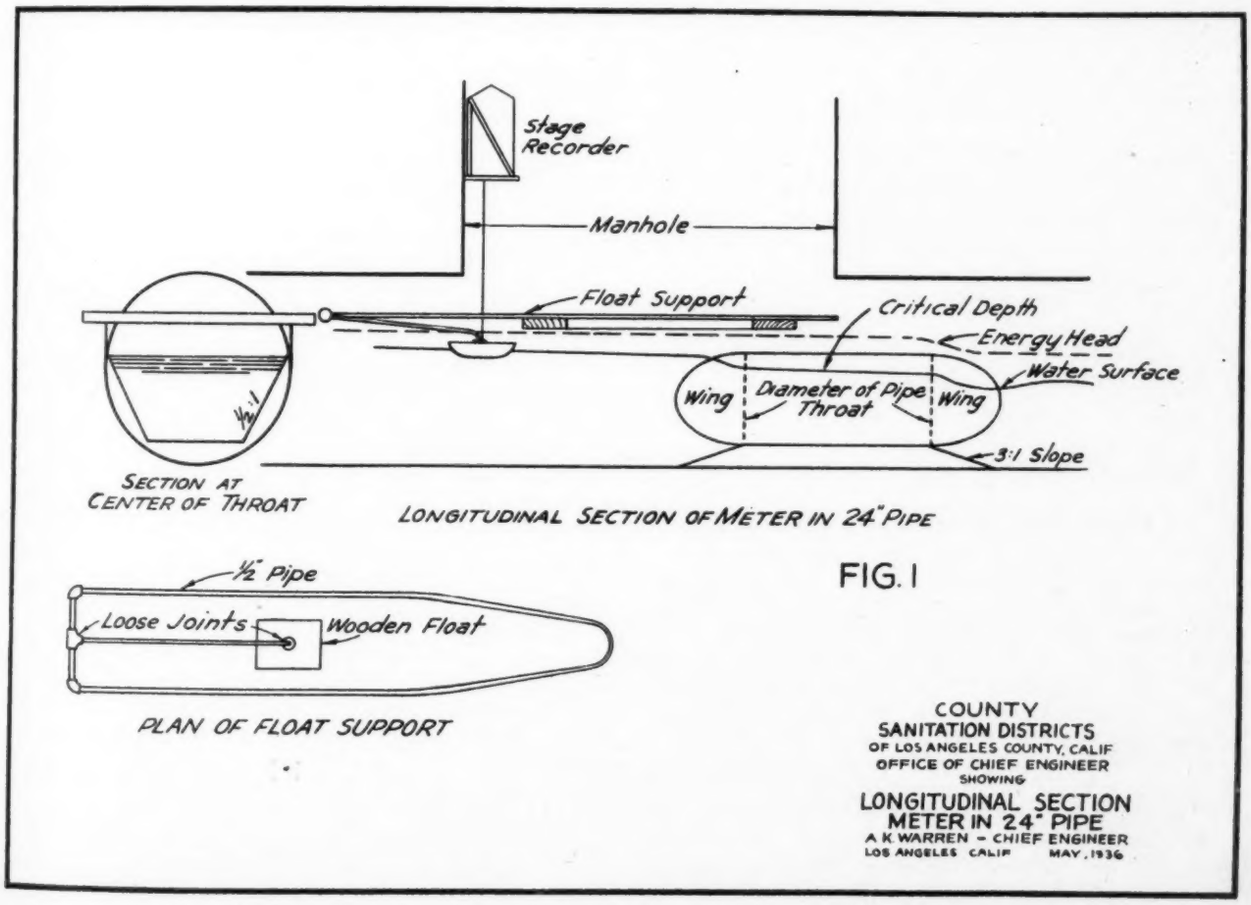


FIG. 1

Venturi Type Flume for 24-Inch Sewer, Showing Float and Recorder Arrangements

the elevation of the energy head in the throat, less the velocity head at the point of measurement, or

$$Y = E - V^2/2g$$

where Y = the elevation of the water surface at the point of measurement.
V = the velocity at the point of measurement.
E = elevation of the velocity head in the throat.

At the same time the elevation of the energy head in the throat must be higher than the energy head in the conduit below the flume.

These conditions hold only when the various filaments of the flow are parallel or nearly so. If the throat is too short, there will be no point in the throat where they are parallel and the critical depth obtained may refer to some datum below, where the channel is enlarging and conditions are uncertain. Should the throat be too long, there will be a wasting of energy and a correction will have to be applied to the critical energy to equal the energy at the point of measurement. Experiment has shown that good results are obtained when the length is equal to the diameter of the pipe, although there is a field here for further experiments.

The Flume Formulae

The value of the energy head can be computed for various shapes of flumes by the following formulae:

For a rectangular flume—

$$Q = 3.09\ bE^{1.5}$$

For a triangular flume—

$$Q = 2.297\ pE^{2.5}$$

For a trapezoidal flume—

$$Q = 3.06\ (b + 0.72pE)\ E^{1.5}$$

in which

Q = the flow in cubic feet per second
E = the energy head in feet above the invert of the throat
b = the bottom width of the flume
p = side slopes of the flume, horizontal/vertical.

No attempt has been made to develop an empirical formula to cover all sizes and shapes of flumes as it would be too cumbersome for practical use. The method of subtracting the velocity head at the measuring point from the energy head is exact within the accuracy of the recording instrument and can be relied upon in all cases. To use an empirical formula it would be necessary to fit a flume of exactly the right size in a given sewer and the formula would hold only between certain limits of flow.

Thus the formula for the flow through a 6-inch flume in a 12-inch pipe can be written:

$$Q = 2.40\ h^{1.64}$$

for (h) less than .34 ft. and

$$Q = 3.20\ h^{1.90}$$

for (h) greater than .34 ft.

Rating Curves and Accuracy

It is easy to figure exactly what size flume is to be built and how high it shall be above the invert, but when it comes to building it during the limited time the flow can be stopped, or perhaps while some sewage is flowing, it may be that the finished flume departs from the plan. If the crest is level, a small change in the width, or the side slopes, or the height above the invert need not affect the final results, because it is only necessary to measure the throat and the channel sections as they exist and draw a rating curve to fit.

The accuracy of these flumes is still a matter of some question as there have not been sufficient opportunities to compare them with reliable meters, but a comparison between a Parshall meter and a temporary flume installed in an irregular channel showed an error of 4 per cent, so it is felt that under ordinary conditions the error should be about 3 per cent, and under very good conditions perhaps 2 per cent. The slower the water flows at the point of measurement, the more accurate the results will be, but if this velocity is too small, sludge will deposit. When the velocity is high there is a tendency for waves to form, making the determination of the depth uncertain.

These flumes cannot be installed in sewers laid on so steep a grade that water normally flows at less than the critical depth, because any obstruction would cause it to jump to the conjugate depth. Referring to the table of flows in the 12-inch rectangular flume: if 1 c.f.s. were flowing 0.2 feet deep at a velocity of 5 feet per second with an energy head of .588 feet, any obstruction would cause it to jump to the other depth having the same energy head—namely, between 0.5 and 0.6 feet. There would be a loss of head in this jump so the depth probably would not exceed 0.5 feet but this increased depth would be sufficient to reduce the capacity of the sewer. If the sewer were being built it would be possible to insert a section of a larger pipe, but if it were an old sewer the Venturi-flume could not be used.

Experiences

Mr. F. D. Bowlus, resident engineer, and the writer, began the experiments for these flumes in 1932 for The Los Angeles County Sanitation Districts, when the flow in the sewers had increased to such an extent as to make weir measurements uncertain. Since that time 16 flumes have been built, and more are to be built in the future. None have given any trouble from clogging and the results have been very satisfactory.

A. K. Warren is Chief Engineer and General Manager, and A. M. Rawn is Assistant Chief Engineer, of The Los Angeles County Sanitation Districts.

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Los Angeles County Outfall Sewer Deep, Difficult and Costly

At a cost of $3,000,000, Los Angeles County Sanitation District is constructing a 7 mile long outfall sewer through deep tunnel, of 8 ft. horseshoe design under the Palos Verdes Hills and under the ocean floor to the outlet one mile off shore at White Point.

Thought to be the depest sewer in the world, at one point it is 600 ft. below ground surface and notwithstanding the difficulties encountered in the 3,000 feet of tunnel construction there has been no error in alignment exceeding ¾ inch. Due to the confused geological structure (a find to geologists, a pain in the neck for the engineers) contractors have had much difficulty which has necessitated 6 changes in excavation methods in the 3,000 foot run. Water troubles, crude oil seepage and flowing sands have added to the problems and a pocket of deadly hydrogen sulphide gas necessitated extraordinary ventilating methods.

Construction of the submerged ocean outfall proceeds at depths of 100 feet below the surface with 18-ton sections of flexible jointed concrete pipe laid in a blasted trench 20 feet deep. The trench is graded with crushed rock by divers working in 4 to 1.5 hour shifts. The design of the ocean outfall has involved many novel experiments and much that is new has been developed. The cost of the completed project will be $3,000,000 (PWA Grant $972,000) for the 7 mile sewer which will make activated-sludge treatment no longer necessary and the overtaxed plant at Harbor City will be utilized as a primary treatment plant discharging settled sewage to the outfall.

WHAT IS CLEAN DRINKING WATER?

By HARRY U. FULLER

Chief Engineer, Portland Water District, Portland, Maine.

A QUALITY of water that was satisfactory to the average consumer a few years ago is not satisfactory today.

With the passing of the years, more is learned by specialists in water supply and more demanding is the consumer. And, it may be that in the next few years we will see even greater changes, but, even now, to the water works man, certain things are increasingly obvious. Furthermore, individual states have established Boards of Public Health and given them great power in bringing about improved water supply.

Chemists and bacteriologists have found ways to measure the degree of pollution of drinking water and have developed methods to effectively purify and sterilize it. Sanitary engineers have evolved various types of filters, and allied purification equipment, that deliver a water free from disease and, for most of the time, palatable.

The cost of filtering water is considerable, but in many places there is no alternative. There are other waters in some parts of the country of such quality that filtering is not now necessary, but that do require chlorine to some degree to make them assuredly safe to drink. The standards set by Boards of Health are gradually changing and the point at which residual chlorine must be found is steadily moving toward the faucet of the last water taker.

These changing standards raise the questions: (1) What is clean, safe water? (2) Where is there a water that is so good that it will be considered satisfactory fifty years hence?

An Ideal Water

There are springs from which flow a crystal-clear, sparkling, cool water. It has been filtered through natural sand beds and is soft, refreshing, invigorating. It is tested by the chemist and bacteriologist, who finds no signs of any form of pollution. It is a clean and pure water. Its temperature is around 50 degrees, and those who drink it proclaim it perfect.

This is the water that ancestors of those now living drank for countless generations. Our fore-fathers adapted themselves to its use, and found it pleasing. Those now living inherited a natural desire for this same type of water and something less appealing to his psychology or his palate is only tolerated. It would seem in the light of our present knowledge, that the above mentioned spring water comes as near to perfection as any we are able to imagine.

There are lakes furnishing municipal water supplies that approach the idealized water from the spring. However, in many lakes and wells the water is found very satisfactory for a goodly part of the year, but at certain seasons the quality becomes noticeably less perfect. One of the causes of trouble in many surface waters is the growth in warm weather of vegetable matter and algae and their subsequent decay. The accepted method of dealing with this condition is the application of copper sulphate or chlorine or both.

Pure vs. Safe Water

The presence of dead and disintegrated vegetation in water, instead of live vegetation, may be less objectionable but the substance is still in the water and the product can not be held to be *pure*—regardless of how *safe*. Much chlorine must be added to the water to oxidize the vegetable matter, or its end products of degredation, before any residual remains to perform the duty that chlorine seems best able to perform. Unless some better method is made available to kill the undesirable bacteria that sometimes find their way into our drinking water, chlorine must continue to be largely used.

A method of effectively and economically controlling the growth of vegetable matter, or of its elimination from waters that do not otherwise require filtering, would be very helpful.

In a large lake that is the source of a municipal water supply, it is possible in May to look down from a boat through 25 feet of water and see the end of the intake pipe. In August the water has taken on a blue-green tinge of color and the intake pipe is no longer visible. This color is caused by the presence in the water of vegetable matter, living and dead, which is practically the same specific gravity as the water and settles very slowly.

In this particular plant the quality of the water is such that no filter is required and during the colder seven months in the year, one to two pounds of chlorine to the million gallons is enough to kill any chance polluting bacteria and leave a small residual as an extra factor of safety. For the other five months greater amounts of chlorine must be added in order to overcome the load of organic matter. Finally, five pounds of chlorine to the million gallons is reached. If more is added, complaints of bad taste are received. And, with the production of the chlorinated organic compounds the taste hazard exists, even in the absence of excess chlorine. The use of copper-sulphate does not improve the taste, and dead algae are no more pleasant to drink than live ones.

In this particular water-works there are so-called dead end troubles where the water in the summer becomes very unpalatable in parts of the system where there is a low rate of flow. The presence of decomposing vegetable matter and depletion of oxygen in the water, with consequent anaerobic conditions set up in these parts of the system, is undoubtedly largely responsible for this condition.

A Needed Solution

It is true that a filter plant would largely overcome such troubles, but at so great a cost that there is considerable reluctance to go to the necessary expense.

With the increasingly higher quality of water demanded by the consumer, it can be seen that the day will come when a filter plant must be built unless some way can be found to overcome this one deficiency—

The author of this article has the distinction of being President-elect of the New England Water Works Association.

namely, the presence of vegetation and its subsequent deposition in the mains, in an otherwise excellent water.

Another water works taking its supply from a small shallow lake finds it necessary to add 20 pounds of chlorine to the million gallons in order to satisfy the demand and leave some residual. The result is a very pleasant tasting water, but the community cannot afford to build and operate a filter plant.

If for water supplies, needing only the elimination of vegetable matter and the addition of a small amount of chlorine to make it satisfactory, a practicable and economical way to eliminate the vegetable matter can be devised, the resulting product should be superior to most filtered waters.

There are throughout the country many water works in such need and it would seem that some method of over-coming this particular difficulty, at a cost more reasonable than the extensive structures and current vogue for filtration entails, is greatly needed.

If the previously described spring water is acceptable as the most nearly perfect water of yesterday and today, we believe that it will be 50 years or more from today. And, in it, we have a standard for comparison of all other waters. The nearer we can produce such a water the most satisfied will the water management and the consuming public be.

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Hammond's New Filter Plant Goes Into Operation

On August 8th, after an appropriate dedication program, the new 20 M.G.D. filtration plant at Hammond, Indiana, was officially accepted and placed in operation. With effective preparations and formal invitations issued by the Board of Trustees of the Water Department, the dedication exercises opened with a banquet; closed with an inspection of the plant and "Open House" for the public at large. Amongst the many notables and prominent men on hand was Indiana's Senator, Frederick Van Nuys, who delivered the principal dedication address.

Briefly, the new plant consists of the following units:

Intake Crib—1 mile off shore.
Low Lift Pumping Station (3 units)—Capacity 50 M.G.D.
Mechanical Flocculating Chambers (8 units);—30 minute detention.
Sedimentation Basins (2 units)—4 hour detention at 20 M.G.D.
Filters (8 units of 2.5 M.G.D. each)—Capacity 2.0 M.G.D.
Clear Water Reservoir—Capacity 5 M.G.D.
Wash Water Tank—Capacity 100,000 Gal.
High Lift Pumping Station—Capacity 45 M.G.D.

Hammond's New Plant (Reproduction of the sketch on the front cover of the elaborately produced Dedication Souvenir Booklet).

In the treatment facilities provision has been made for pre-chlorination (with or without ammoniation); the use of alum or chlorinated-copperas; any degree of mixing and flocculation desired; lime feed for pH adjustment and corrosion control; post-ammoniation and chlorination to maintain residual throughout the system. The plant structures cost $415,000; filter equipment and piping $166,500. The completed project, including engineering and interest, was financed through a P.W.A. loan and grant at a cost of $821,000.

Consulting Engineers on the project were Greeley and Hansen of Chicago; Supervising Engineer on the project, Leo Besozzi, is now Superintendent of Filtration; Lloyd E. Bussert* is Purchasing Agent and Chief Operator; Robert A. Wilkin is Chief Engineer of Pumping Stations; J. C. Vaughn is Chemist; and E. C. Dowling is Supervisor of Distribution.

A five man Board of Trustees, headed by Percy T. Smith, manage and operate the Department of Water Works which was established by legislative acts in 1933 as a public utility divorced from other public works of the city.

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Mathew Braidech Joins Case Faculty

M. M. Braidech

Mathew M. Braidech, on September 1st, resigned as Chief Chemist at Cleveland's Baldwin Filters to accept an appointment on the faculty of the Case School of Applied Science at Cleveland. On September 15th he takes up his new work as Assistant Professor of Chemical Engineering at the Case School but will not be entirely divorced thereby from the field of water supply in which he has won his spurs and honors—the most recent being the 1936 award of the Goodell Prize by the American Water Works Association for "a notable contribution to the science of water supply development."

Mr. Braidech, a 1925 graduate Chemical Engineer from Ohio State University, has been connected with Cleveland's Department of Public Utilities in one or another capacity during the past 10 years. For his investigations and studies pertaining to taste and odor control at Cleveland, and his masterful papers on this subject—more specifically the ammonia-chlorine process—he received the honorary degree of Professional Chemical Engineer from his *alma-mater* in 1931. He has much to his credit in the way of experimental and the development work within Cleveland's Water Department, including the construction and operation of a pilot purification plant.

In recent years Mr. Braidech has become best known for his indefatigable work as Chairman of A.W.W.A.'s Committee on Specifications and Tests for Powdered Activated Carbons—the value of the latter work being only partially appreciated by those who must purchase and depend upon carbon for qualities other than its black color and ability to make dust.

In his new work Professor Braidech will head Case's Division of Fuels, Oils and Water Technology. He, therefore, is not entirely lost to the water works fraternity, which he has served so tirelessly and so well.

*Mr. Bussert arranged the Dedication Program and produced the very excellently illustrated and descriptive Dedication Souvenir Booklet.—Ed.

A Typical Section of Right of Way Along the Pequannock Conduits

EXPERIENCES IN REHABILITATING LARGE WATER MAINS

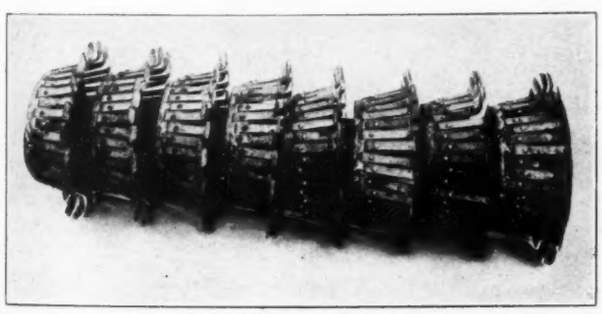
How Cleaning and Cement Lining of 40-Year-Old Main At Newark, N. J., Raised Its Capacity to Better Than That of the Main When New

By WM. G. BANKS[1] and A. CLINTON INGLEE[2]

THE City of Newark, New Jersey, early in 1934 adopted a program of work required to correct deficiencies both existing and imminent in carrying capacities in its aqueduct system conveying water from the Pequannock Watershed to the city. This work program, involving a total of 50 miles of 32 to 46 year old riveted steel pipe-lines ranging in size from 36 to 60 inches in diameter, has as its ultimate aim first to restore capacity lost through excessive tuberculation and to insure additional years of service and second to provide an alternate route to convey water from the main distributing reservoir at Cedar Grove to the distribution system. It is to be accomplished over a period of five years by a step-by-step procedure of reconditioning and some replacement of existing pipe-lines and the addition of a comparatively short section of new pipe connecting portions of the Pequannock Aqueduct system.

The major portion of this proposed work, approximately 75 per cent of the total length involved, consists of reconditioning the pipe lines by cleaning the interior surfaces of the pipes and applying thereafter a protective lining. The imporatnt aspect in addition to the fact that the work restores the original capacity, is the assumption that the lining will protect the steel surfaces and prevent the recurrence of tuberculation, pitting and loss of capacity.

[1]Division Engineer, Water Department, Newark, N. J.
[2]President and General Manager, National Water Main Cleaning Co., New York, N. Y.
(Note.—This paper was presented by Mr. Inglee before the American Water Works Association, in Annual Convention at Los Angeles, Calif., June 10, 1936.)



The Type of Cleaning Machine Which Was Mostly Used in the Project. It Has 800 Steel Teeth.

Original Aqueducts

The reconditioning program is possible because of the fact that two parallel lines extend for the entire distance from the collecting reservoirs to the large distributing reservoir at Cedar Grove. It is apparent that considerable care was taken in providing a protective lining on the interior of the pipes when they were laid. A selected bituminous material was applied by dipping. Each pipe was twice dipped in this heated bitumen. Where an appreciable thickness of lining occurred it is still in place and is still offering complete protection to the steel surfaces beneath. Elsewhere tuberculation has occurred with pittings under tubercles extending to a depth of 0.125 inch, the largest pittings having a diameter of about an inch and a half. The extent of tuberculation of the lines is indicated by a reduction of carrying capacity to about 70 per cent of the original. Nowhere has interior corrosion weakened the pipe appreciably. The loss in strength is estimated as nowhere more than 5 per cent. In places rather serious exterior corrosion has taken place. This has occurred in locations subject to special conditions, in general of an electrolysis nature. At such points perforations develop from the outside and leaks occur, sometimes frequently. One particularly bad stretch of 36-inch steel line 2700 feet in length through wet clayey soil in one of Newark's parks has been replaced. Other short sections of this same pipe are in bad condition and scheduled for replacement. Not until the reconditioning work has advanced considerably will we have even an approximate idea of the amount to be replaced. In the program of aqueduct reconditioning the sections of pipe scheduled for replacement totaled 40,000

feet. With reconditioning work costing about one-fifth of the cost of replacement, it is evident that replacements are contemplated only where essential.

Characteristics of Newark Water

The water of the Pequannock Supply is an unfiltered aggressive surface water, soft in character. For many years when the aqueduct was first placed in service chlorination was not employed. Chlorine treatment began in 1923 and since 1932 ammonia has also been applied as required for effective chloramine treatment. Average chemical characteristics of the water are:

pH	7.0
CO_2 (free)	1.0 to 3.0 p.p.m.
Dissolved Oxygen	9.0 p.p.m.
Total Alkalinity	24.4 p.p.m.
Iron	0.2 p.p.m.
Sulphates (SO_4)	10.7 p.p.m.
Calcium (Ca)	9.0 p.p.m.
Total Solids	53.8 p.p.m.
Color	23.0 p.p.m.

During its 40 years of service water of the above type, with changes due to heavy rain-fall, has been fed through the Pequannock Aqueduct.

Chemical analyses of the representative tubercules taken from the pipe walls show the following composition:

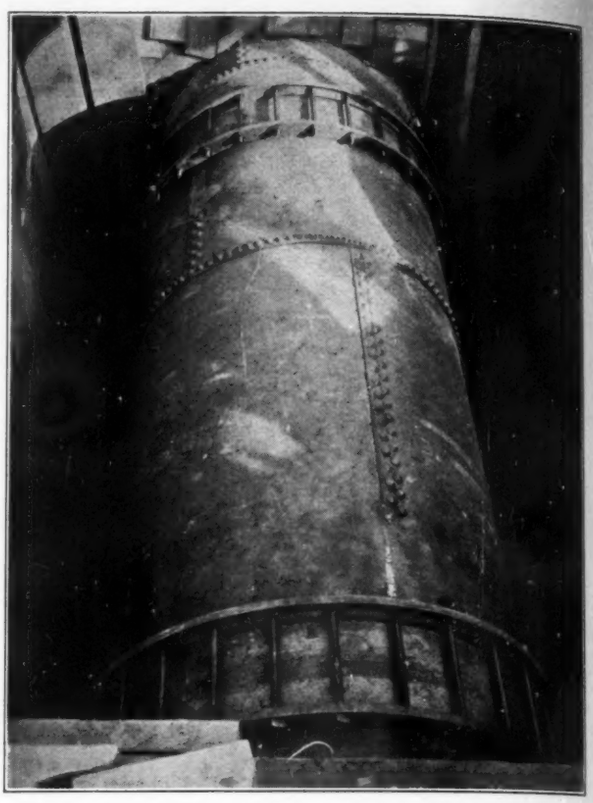
Oxides of Iron and Aluminum	78.25%
Silica (SiO_2)	5.00%
Sulphate (SO_4)	1.34%
Calcium (Ca)	0.50%
Loss on Ignition	13.80%

Experiences with Bituminous Enamel Lining

The first reconditioning work was undertaken in 1933 and consisted of cleaning the tuberculated interior of 40-year-old, 42-inch diameter riveted steel pipe, made up in 7½ foot courses, and recoating with bituminous enamel applied hot over a priming solution applied cold to the carefully cleaned and dried surfaces. Difficulties were encountered towards the end of the work, with moisture on the steel surfaces in the line, caused by differences in temperature between the warm outside air and the pipe metal. It was necessary to put the line back in service for high rates of draft due to warm-weather consumption. The line continued in service until the reconditioning work was resumed in October, 1935. At this writing the work is still in progress. Difficulties due to condensation of moisture on the pipe walls are now apparently under control.

This main was laid with manholes 800 to 1000 feet apart and with 1¼-inch rivet pass-holes in the top of the pipe at 30-foot intervals. Only the man-holes and pass-holes were uncovered and opened, for the bituminous lining project. During operations the pipe is lighted by electric lights and is ventilated by suction fans located at the manholes. Each painter is provided with a hand light which he holds in one hand while applying enamel with the other.

In ventilating a section, a bulkhead is placed just beyond the manholes which limit the section, and a fan is located above one of these manholes. As it is necessary to use the manholes for the passage of men and materials, the fan cannot be set directly in or on it, but an "air lock" is used—a small, square frame shed over the manhole, in the roof of which is set the exhaust fan with a vertical shaft carrying its weather cased motor on top. The fans are of 3500 cubic feet capacity and give a



A Section of 48 In. Main Equipped With Dresser Couplings for Ease of Removal to Insert Cleaning Machine.

velocity of air through the pipe of 3 feet per second. As the air in the pipe is used by a great number of men, ventilation is necessary to carry off the dust caused by the scraping and brushing and the fumes from the priming coat and enamel. All scrapers wear goggles and dust-proof respirators, while the painters wear goggles and chemical respirators.

For removing the tubercles the men use two-handed scrapers, which are flattened at the end to an edge about 2 inches wide, which is resharpened at regular intervals. The material scraped off, together with the bottom deposits, is placed in burlap bags and removed at the nearest manhole. Following this, the surface is brushed with motor-driven wire cup-brushes, a ball of steel shavings being placed in the cup to increase the area polished. Finally, just before the surface is painted it is wiped off with rags (purchased in bales) which have been found cheaper and better than waste.

In recoating the pipe, it is first painted with the priming solution applied cold with wall brushes. When this is dry, usually the following day, the bituminous enamel (heated in tar kettles to 425 degrees) is applied, using Tampico fiber daubers. The dauber is dipped in the hot enamel and applied to the pipe surface with a 9-inch stroke, forward and back. It is again dipped and applied, each stroke overlapping the previous one. Using the hand light, care is taken to see that the surface is effectively covered to a thickness of ⅛ inch. An instructor to train the men in applying the coating and the heating kettles were furnished by the manufacturer of the bituminous materials. Extreme care is used to insure the hot enamel being kept at the proper temperature. The enamel buckets are replenished through funnels at the nearest pass-holes—these holes being but 1¼ inch diameter through the top of the pipe. A simple signal system is used to notify the kettle man that the

painter below needs more material. Tar kettles are cleaned at the end of each day to remove any coked material which tends to form and accumulate.

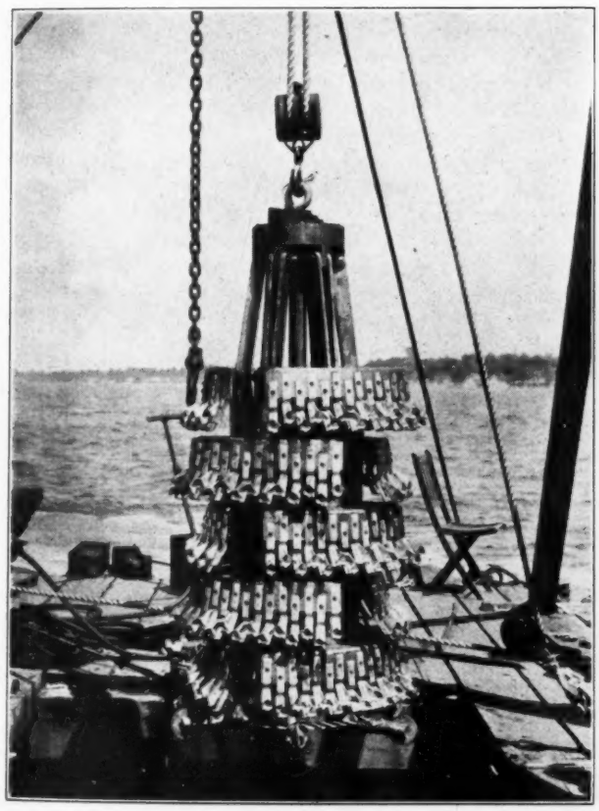
When the coating in a section between manholes has been completed, the entire surface is inspected by a city representative and, when acceptable, the section is isolated to prevent damage to the finished lining.

From the start of the work in 1933 to the date of this writing, about 8000 lineal feet of 42-inch pipe has been completely and satisfactorily reconditioned with the bituminous enamel lining.

Much thought has been given to procedure to enable the reconditioning work to continue as the warm weather of summer approaches and moisture collects on the cold steel surfaces of the underground pipe. Air is now drawn into the pipe through charcoal and ground cork filters located at an opening in the pipe at considerable distance from the location where enameling is under way and in the portion of the pipe which has been already enameled. The charcoal and cork, which is removed and dried twice daily, takes some moisture from the air entering the pipe. The entering air is cooled to the temperature of the underground pipe as it passes through the section already enameled and the condensation forms on the enameled surfaces. By the time it reaches the section where men are working the air has dropped its excess moisture and a dry pipe results. It remains to be seen, however, whether this will be the case during hot muggy days.

Experiences with Cement-Mortar Lining

Work done under contract on the second reconditioning project scheduled was started in November, 1935, and completed in May, 1936. This major project consisted of cleaning 27,800 lineal feet of 40-year-old, 48-inch diameter riveted steel pipe (7½ foot courses) and relining it with a protective coating of cement-mortar to a thickness of ¼ inch. This section of line, one of the Twin Pequannock Conduits, extending from Macopin Intake to Pompton Notch, runs through a rugged and hilly country. Grades as steep as 3 per cent occurred and 10 per cent of the line lays on grades steeper than 12 per cent.



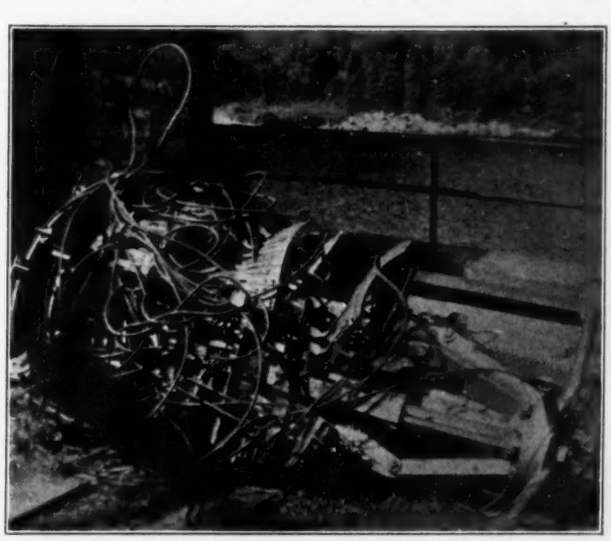
The Collapsible Pipe Cleaning Machine, As It Went Into the Line.

Features of Specifications

The purpose of the exacting requirements of the contract specifications under which this work was done, was to insure a lining which, for many years, would protect the steel surfaces of the interior of the pipe to which it is applied, would cover the surfaces completely and remain in contact firmly with the same, notwithstanding the expansion and contraction of the pipe due to filling and emptying the line, to variations in pressure and to temperature changes. Recent inspections show that there is every reason to believe that this has been attained. A maintenance bond guaranteeing this desired result and covering a ten-year period was furnished by the contractor. This was a special bond furnished in addition to the regular construction and material and labor bonds.

Provisions in the specifications gave the city the right to order all or any part of the work suspended, without any claim on the part of the contractor, in order to place the line in service and replenish the storage in Cedar Grove Reservoir. It was necessary to take advantage of this situation during the past winter when the work was suspended for a period of five weeks in order to refill the depleted storage reservoir due to the lack of carrying capacity of the other twin line during an unexpected peak of cold-water consumption. No more definite proof could have been provided of the truth of the engineer's contentions that this reconditioning work could not be long delayed.

It was anticipated that sections of the line through swamps, stream beds and elsewhere would be pitted on the outside to such an extent that, with the inside pitting, a considerable weakening of the pipe structure would result. Provision was made for linings of various thicknesses greater than ¼ inch in order to reinforce the steel pipe and offer resistance to the loss of water from the line in the future as outside pittings perforated the steel shell. The lining applied to several sections of the pipe was increased to a ⅝-inch thickness after the need thereof was determined in advance by a careful examination of the exterior by means of test pits plus the known condition of the interior as revealed during the cleaning operations. Two short



And—The Same Machine As It Emerged (See Text).

sections, one located under a stream bed and the other under a road crossing were actually lined with a 1-inch thickness for absolute security.

Preparation of the Lime

In preparation for the work of cleaning and relining by contract, the city uncovered and opened all entrance manholes in the section of steel pipe to be relined, of which there were 24 spaced about 1,000 feet apart; unwatered the lines; provided openings in the steel pipe line for the insertion and withdrawal of equipment, at four points; placed bulkheads to prevent any possibility of water in volume entering the section in which men were working; repaired by welding about 10 perforations or deep pittings in the steel pipe walls before the new lining was applied; replaced and recovered all entrance manholes and the pipe sections at the four openings after the contractor had completed the work; refilled the line, sterilized it and restored service through it.

The openings provided for the access of mechanical equipment were made by the removal of an 8-foot section of the pipe which later was replaced and connected with Dresser Couplings. This method provided a section which could be readily removed and replaced as required. The section was taken out intact by making two circumferential cuts, on a slight batter, with acetylene torches. The four ends, two on the removed section and two on the pipe in place in the ground, were adapted to the Dresser Couplings by forming a welded butt joint to fit a 48½ inch coupling.

Cleaning the Line

The cleaning of water mains has become familiar to most water works operators, either from their personal observations and experience or from published articles. In general, the work of cleaning large mains offers no great difficulty providing water under pressure is available and there are adequate facilities for carrying off flushing water and the debris removed during the cleaning operations.

The cleaning of the 48-inch riveted steel line preparatory to cement lining presented some unusual difficulties; first—because the line is telescoped and of lap-joint riveted steel construction in seven foot courses; second—because, in many places, it was considerably out of round and finally—because it is laid so close to the hydraulic gradient that pressure, especially at the beginning of the line is hardly adequate to operate the cleaning machines.

The first section laid out to be cleaned was about thirteen hundred feet long, extending from the intake well in the gate house at Macopin Reservoir to the Venturi meter. Within a few feet of the gate house there is a 22.5 degree short-radius cast-iron bend and from there on the steel pipe follows a wide curve. No opening was to be made at the end of the first run so that the original plan was made and equipment designed to use a cleaner which, after its passage through the line, could be reduced in diameter and pulled back for removal at the intake well. The collapsible type of machine so used is here pictured.

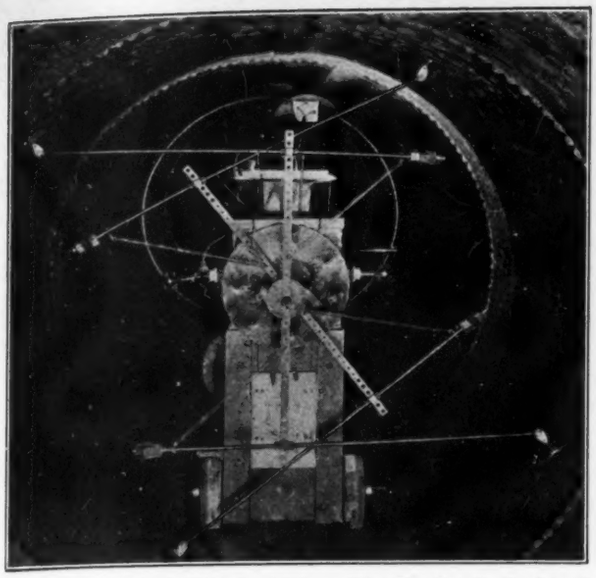
The handling of the machine in the limited space of the gate house and well offered some problems but it was finally entered into the pipe line through a funnel by means of jacks. At first a windlass and cable were used in an attempt to pull the machine but, because of the curving layout of the pipe line, there was too much friction of the cable along the side of the pipe to utilize the full work of the windlass and pulling alone would not operate the machine. Then water pressure alone was tried. The ordinary head of thirteen feet at the gate house was raised to 20 feet, which was enough to start the device but insufficient to move it past the cast-iron bend. The machine was then jacked around this bend with the hydraulic jack and long timbers. The head was again built up to 20 feet but, due to the friction of joints and rivets in the pipe this water pressure was inadequate to start the machine. Therefore, a cable was brought up through the line from the Venturi and attached to the front of the machine. It required both the windlass and cable plus the water pressure to start the machine. Then came real trouble: Once the machine was under way it over-ran the cable—became tangled on it and was badly wrecked. One compensation was that the wreckage traveled to the bulkhead (erected in the line to protect the Venturi meter from damage), after which it was pulled back to the gate house and removed. Upon its removal it appeared as pictured—practically a total loss to the main cleaning company.

Following this experience, another type of machine was entered into the line at the gate house and traveled through with good results, under water pressure alone. This machine was designed and specially constructed by the main cleaning company so that it would be dismantled with a minimum of difficulty inside the pipe line and removed piece by piece. The ordinary type of machine piston first used, allowed so much water to pass and the reinforced scraping units were so stiff that the machine could not be started with the available head. A special air inflated piston was then built, the tension on the scrapers was reduced and the machine successfully shot through the first section. At the end of the run the machine was dismantled from both ends and the pieces were removed through a nearby manhole. The specially constructed machine is but slightly different in appearance to the standard machines used for cleaning large mains.

So that the work of relining should not be delayed by the cleaning it was then decided to next clean sixteen thousand feet at the lower end of the line. The collapsible machine was reconstructed and used on this second section. This was a long run and many scrapers had become worn and broken before its completion. A physical inspection showed that the pipe was about 75 per cent cleaned. After repairs, the machine was again run through the line, emerging in good condition, and inspection showed a satisfactory cleaning job.

For the third operation the line was opened just beyond the Venturi and seventy-two hundred feet were cleaned. The pressure at the Venturi was enough to start the machine which was of the rigid take-down type. The line ran up and down grade. At the low points in the line the blow-offs were opened and large quantities of dirt were washed out at these blow-offs but, even with this relief, the greater part of the removed incrustation had to be carried ahead of the machine at the end of the run. In every instance, after arrival at the low point in the line the blow-off valve was closed—then the debris, being heavier than the water, would begin to pile up ahead of the machine and frequently caused the complete stoppage of the machine on the up grades. When this happened it was necessary to drain the line, enter it ahead of the machine and, with shovels, spread the incrustation for thirty or forty feet along the pipe ahead of the machine. Thus relieved and the water again turned on the machine would travel over the next high point.

The rate of travel could be readily followed as the



The Machine Which Did the Lining. The Reader Is Facing the Centrifugal Head Which Throws the Mortar. In the Rear Is the Feed-Hopper and the Storage Car for Mortar. Note That the Section of Pipe Is a Bit Egg-Shaped, But Was Effectively Lined by Machine.

noise of the eight hundred spring-steel scraping units passing over successive rivets sounded like the droning of a distant airplane. The gate-house valve was used to control the water and the rate of flow could only be changed gradually and after considerable time. The best results are to be expected when the machine travels slowly and continuously along but with the remote control in this line the rates of travel varied from six feet per minute (with stops to allow pressure to build up when going up hill), to two hundred and fifty-eight feet per minute on the down grades.

The fourth and last section cleaned was about 2,500 feet in length. This was also successfully cleaned with the rigid take-down type machine.

Even with all the preliminary study made in connection with the cleaning work, unexpected difficulties would arise and it frequently required all the resources of the contractor's engineers and the city's engineers to overcome these obstacles. In every run, means had to be devised to stop the cleaner in the pipe before it could reach the outlet cut. It was feared that if the machine were allowed to come out freely, as is allowed in cast-iron pipe cleaning, there would be a sudden drop in pressure which might cause a vacuum at some high point, resulting in the collapse of the steel pipe. In order to stop the machine with least damage possible to it, bulkheads of 8 x 8 inch timbers were wedged in the line, then many sand bags laid up to serve as a cushion. For every pound of pressure per square inch behind the machine there were about eighteen hundred pounds of actual pressure, which reveals the force which had to be gotten under control.

Much of the removed material was finely cut and ground by the machine and probably 60 per cent of the total was carried off in suspension, leaving only about 40 per cent to be shoveled out from ahead of the machine at the completion of a run.

Some hand cleaning was necessary in addition to the machine cleaning. In places the old bituminous lining firmly adhered to the pipe and had to be taken off with scrapers and wire brushes. Also, the rust and tubercles between rivet heads and in the deeper pittings had to be brushed out by hand.

The work took a gread deal longer than was anticipated but, in spite of the delays and the additional expense thus incurred, the cost per foot for the primary mechanical cleaning and the finishing work by hand, was very much less than the cost of the all hand cleaning which had been practiced on previous work.

Representative sections of the pipe were carefully scraped, the areas measured and the incrustation weighed, from which it is estimated that one hundred and five tons of incrustation were removed from the 28,000 feet of line cleaned in this manner.

The equipment used in the application of the cement-mortar lining consisted of the mixing and power plant located on the ground level and the lining apparatus operating in the pipe. The first consisted of two gasoline driven paddle-type mortar mixers, the necessary water and material storage facilities, and a portable gasoline-driven motor generator plant. The second, all independently driven by electric motor through cable from the mobile power plant, included the centrifugal lining machine, a traveling screw conveyor equipped with a storage hopper, and a delivery car for transporting the material from the man-hole at the mobile mixing plant to the lining equipment in the main. Current was supplied by the power plant to the various units through cable wound on reels.

The mortar delivery car is an electrically driven pneumatic tired buggy, with steering facilities on both front and rear wheels and is equipped with a small hand operated hydraulic dumping rig. The body capacity is 7.0 cubic feet, each load being equivalent to 26 lineal feet of ¼-inch lining on a section of 48-inch diameter pipe. The delivery car requires one operator who receives the mortar at the access manhole and delivers and dumps it into the hopper of the conveyor attached to the lining unit.

The conveyor consists of a traveling hopper-type storage truck, equipped with an inclined feed screw and operates directly behind the main centrifugal unit of the lining machine. The travel speed of the storage truck is synchronized with the travel of the centrifugal lining machine. The truck is provided with pneumatic tires and is electrically driven by an independent variable speed motor for traction together with a slow speed shaft which drives the inclined screw, feeding mortar to the centrifugal machine. The hopper is of the same capacity as the delivery car, this storage providing ample time for the delivery car to make a round trip to the access manhole.

The lining machine is a centrifugal device equipped

Mortar Mixing Operations at One of the Entrances to the Main. Note Dryness of Mortar (1 *Cement*: 1 *Dry Sand by Weight.*)

with two electric motors, one for traction with a variable speed transmission, the other of constant speed which drives a short screw-feed conveyor, the mortar lining head and a set of slowly revolving finishing trowels. (See illustration.) A small hopper, of one cubic foot capacity, is mounted on the centrifugal unit and receives mortar from the conveyor previously described. A short slow speed screw, operating in this hopper, forces the mortar at a constant rate from the small hopper directly to the center of the 6-inch cylindrical lining head, around the circumference of which are rectangular or slotted ports. As the mortar passes through the ports it is thrown against the pipe wall with great force, by radially spaced high speed vanes which rotate outside of these fixed ports, at a speed of 1,000 r.p.m. The actual lining head revolving at this high speed depends entirely on centrifugal force for placing the mortar. The high-speed shaft driving the lining head is hollow and in the interior is a slow-speed shaft turning at only 3 r.p.m., upon which are mounted four steel trowels which follow directly behind the lining head, two operating clock-wise and two counter clock-wise. The trowels are so designed and adjusted that their curved surfaces smooth and finish the lining after placing.

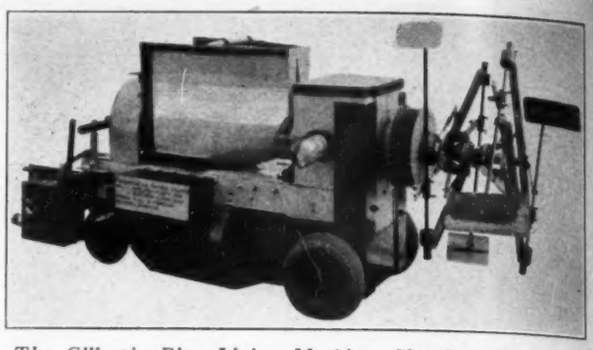
The equipment as a whole is extremely flexible and provides a means of placing a lining of variable thickness. The travel speed of the lining machine can be so slowed down that thicknesses as great as may be desired can be obtained; or, so speeded up that thicknesses of any practical desired minimum can be obtained.

Application of Cement Lining

The lining application procedure for a day's run was as follows:

The lining and conveying units were assembled in the pipe and adjusted to start operations at the end of the previous day's work and the mixing and power plants were set up at the next entrance manhole, or access opening located at the end of the day's run, which arrangement permitted the lining operations to progress towards the mixing and conveying units. The mortar being mixed for at least six minutes was chuted through the opening to the dump car, transported to the conveyor, loaded in the storage hopper of the centrifugal lining machine, and applied by the machine while the dump car returned to the mixer for another batch of mortar. After the lining operation had advanced to a point near the opening at the mixing plant, the working parts of the lining and conveyor units were removed, taken from the pipe and cleaned preparatory to the next day's work, the mixing and power plants moved and set up at the next opening and the procedure repeated. The cement and sand, after receiving special treatment at the contractor's plant, were hauled to the work in bags of 85 pounds each. Water stored in barrels at the mixing plant was fed to the mixer with measuring pails. Perfect control of the water-cement ratio was easily maintained due to the fact that the moisture content of the sand had been removed by drying operations preparatory to careful sand grading, and bagging at the contractor's central plant.

At points along this line where entrance manholes were spaced more than 600 feet apart, the contractor provided additional openings by removing a rectangular section of the steel plate 30 inches long by 24 inches wide. These plates were replaced by welding prior to the lining of the pipe at this point, so that the cement-mortar lining was continuous and unbroken past these locations.



The Gillespie Pipe Lining Machine, Showing Clearly the Mortar Distributing Multi-Toothed Centrifugal Head Behind the Smoothing Trowels

To protect appurtenances, such as blow-off, air-valves and manhole connections, wooden plugs were inserted, so arranged as to be easily removed without damaging the lining after the machine had passed and the lining had set.

The specification, as applying to the curing of the lining, required that immediately upon the completion of the lining of a section of pipe between manholes, or at the end of a day's run of the machine, the section of pipe should be closed off at both ends, manhole openings covered, and steam introduced into the pipe between the bulkheads. The section of pipe is kept filled with steam until the mortar lining has set satisfactorily. In no event was this period of steam curing allowed to be less than 48 hours. Bulkheads and manhole covers were required to be kept in position to prevent circulation of air and to keep the mortar lining moist until it had set completely in the judgment of the engineer; and if necessary the cement-mortar surfaces were to be sprinkled in addition.

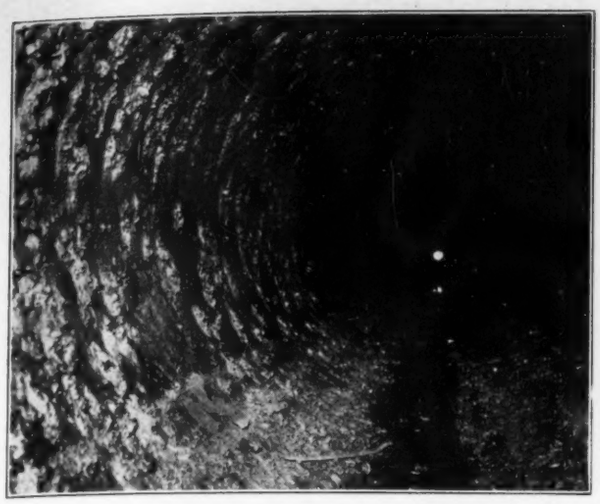
Steam for curing was generated by small portable boilers using coke as fuel. And at the end of about 4 hours from the time of completion of the lining (by which time the mortar had attained its initial set), steam was introduced into the section.

The ingenious bulkheads were made of a sheet of rubber cemented to a ring made to the diameter of the pipe from sections of rubber tire inner tubes vulcanized together to form one large tube. By inflating the tube the bulkhead could be made to fit tightly into the pipe. Thereafter, by deflating, it could be easily and quickly removed at will and carried from section to section.

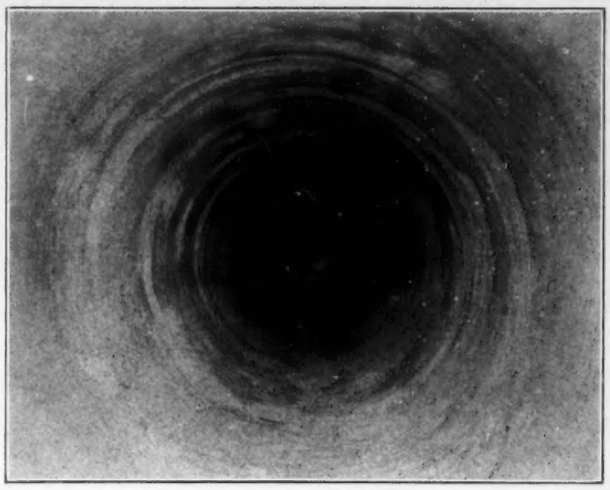
The work was carried on in one 8-hour shift but at times overtime was required. A section between access openings, which averaged 500 feet in length, was the usual day's run irrespective of whether ¼-inch or ⅝-inch lining was being placed. Under favorable conditions, two 500-foot sections of pipe could be lined, if the lining was ¼-inch. The maximum day's run for ¼-inch lining was 1088 linear feet. The rates of progress were determined somewhat by the steepness of grades and by the rates at which the dump car could convey mortar to the lining machine rather than by the rates at which the machine could place the mortar lining. The machine rate was slightly more than 3 linear feet per minute for ¼-inch lining and slightly less than 2 linear feet per minute for ⅝-inch lining.

Selection of Sand and Cement

The contract specifications pertaining to sand, cement and water for the mortar lining were as follows: "Mortar for the lining shall be a mixture of Portland cement and effectively screened sand and shall be of the proper consistency to provide a dense, homogeneous lin-



40 Years Old: A Representative Section of the Pequannock 48 In. Steel Supply Main. "C"=70.



40 Years Young: A Representative Section of the Line After Cleaning and Mechanically Lining With Cement Mortar. "C"=124

ing which will hold itself firmly against the pipe surfaces; and the water-cement ratio shall be carefully controlled. Due allowance shall be made as necessary, for moisture existing or collecting on the walls of the pipe. Cement shall conform to A.S.T.M. specifications C-I-30. Sand shall be clean, sharp, graded, free from organic matter and with no grains larger than will pass a 12-mesh screen. The proportions of cement and sand in the mortar for the lining shall be one to three parts of Portland cement to one part of screened sand by volume (actually 1 to 1 by weight if dried sand was used). The mortar shall be mixed by machine for a sufficient length of time to obtain maximum plasticity, in general for at least five minutes, and shall be used promptly for lining the pipe. No mortar which has attained its initial set shall be used."

In preparation for the cement lining work two of the first considerations before the contractor were the selection of the sand and the brand of cement to be used.

Previous experimental work over a period of several years had determined the general characteristics of the sand which gave best results. Two typical analyses showed the following characteristics:

	Per Cent	Per Cent
Passing 200 mesh sieve.....	1.01	0.72
Passing 100 mesh sieve.....	6.44	6.58
Passing 80 mesh sieve.....	10.25	9.97
Passing 50 mesh sieve.....	46.87	39.54
Passing 30 mesh sieve.....	30.39	40.00
Passing 20 mesh sieve.....	3.46	2.76
Passing 12 mesh sieve.....	1.58	.44
Total	100.00	100.00
Specific gravity of mineral.....	2.666	2.665
	Lbs. per cu. ft.	
Weight, solid mineral.....	166.36	166.30
Weight loose, dry sand.....	94.34	93.69
	Per Cent	Per Cent
Voids, loose, dry sand.....	43.3	43.7

After analyses and tests of this and other sands, the contractor's sand was accepted for the work.

Samples of fifteen different Portland Cements were submitted by the contractor, designated only by a number. These were subjected to the customary standard tests: fineness, specific gravity, soundness, initial and final setting times and tensile strengths with standard Ottawa sand. Tensile strength tests with samples of same proposed for use were also made. Chemical tests were made for silica (SiO_2), lime (CaO), Alumina (Ai_2O_3). Samples were tested for low-solubility; non-leaching, minimum-shrinkage and slow-setting qualities which were deemed necessary for a mortar which was to be applied from ¼ to 1 inch thick on the interior of the pipes.

From a consideration of the chemical analyses of the fifteen cements, nine were selected as best suited, chemically, for the work. Because, for its hydration (setting and subsequent hardening) cement relies almost wholly upon its calcium oxide (CaO) and its silica (SiO_2) as large an amount as possible of these was desired. Cements low in iron content (Fe_2O_3) and in magnesium (Mgo) were given preference. As contraction of the mortar was a very important matter, especially when it is appreciated that 48-inch diameter pipe has a circumference of about 12 feet and the thickness of lining might be as little as ¼ inch in thickness, a normal aluminum content (Ai_2O_3) was desired as helping to prevent contraction and the formation of cracks in the mortar lining. From physical tests of these nine selected cements, four approved cements were finally chosen. Of the physical tests the chief consideration was the time-of-set. Since the mixing of the mortar, the transporting of it into and through the pipe, its application to the pipe and its troweling and finishing to a smooth surface required more than the ordinary amount of time it was thought best that the cement recommended should have a long time for initial set as well as a long time for final set. Satisfactory tensile strength when mixed 1 to 1 with the approved sand was also a requirement.

Four cements were finally certified to the contractor as best suited for the particular work. From these the contractor made his selection of brand, only one brand being used for the entire work. Each carload as received on the work was sampled and subjected to A.S.T.M. standard test. To avoid any possibility of lumps of cement, pieces of bag twine or wire, or other foreign substance clogging or injuring the lining machine all cement was passed through a 16-mesh screen and was then rebagged. Sand was heated and dried, passed through a 12-mesh screen and bagged. Each bag of sand and of cement contained 85 pounds. This facilitated the making of the mortar mixture which was 1 to 1 by weight.

As the mortar applied to the interior of the pipe was

to be kept moist during curing only enough water to completely hydrate the cement in the mortar was considered desirable in order to reduce shrinkage of the mortar to a minimum. This was carefully determined in the laboratory and rigidly adhered to throughout the work. The water-cement rate of the mortar was 0.32. The density of the finished lining is shown by the results of tests made on samples cut from the lining about a month after it was placed, showing a volume specific gravity of 2.29 and a water absorption of 5.53 per cent of the dried sample as determined by A.S.T.M. D-30-18. Twenty-eight day tensile strength tests of the 1 to 1 mortar averaged about 825 pounds per square inch.

Hydraulic Results of Reconditioning

As yet it has been impossible to make tests to determine the effect of the new bituminous enamel lining on the carrying capacity of the reconditioned lines.

It is believed that the lining of the section of 48-inch riveted steel pipe line with cement mortar lining has given it a greater carrying capacity than it had even originally when new. A measure of the ability of a pipe to carry water is given by its so-called Hazen Coefficient. For instance, if the value of this coefficient, designated as C, is 100, its capacity is twice as much as the capacity of pipe of the same size whose C is 50. The first records which we have from tests made of this line to determine the Hazen "C" of this pipe were obtained in November, 1923, when the pipe was 27 years old and the "C" equal to approximately 80. From time to time between 1930 and 1935 similar observations were made which showed progressively lessening values of "C" to 70 when the reconditioning work was undertaken.

Upon the completion of the machine cleaning of the line, preparatory to the placing of the cement lining, a section of the cleaned line about 12,000 feet in length was observed to have a coefficient of about 110. This is probably an indication of the coefficient of the pipe when new. Because of the fact that the 48-inch riveted pipe has short courses about 7-feet in length with tapered sections, lapped joints and full rivet heads on the inside of the pipe, it seems unlikely that the value of "C" was ever more than 110.

Tests of a finished section of the cement lined pipe show a coefficient of 124. The tests were very carefully made in a stretch of pipe 16,000 feet long, lined for the most part with ¼-inch cement-mortar lining. The coefficient is based on the 48-inch nominal diameter of the pipe and not on the actual reduced diameter of the lined waterway. It is evident from this, that the smoother contour of the cement-lined surface lessens the disturbances in the flowing stream enough to more than offset the reduction in area of waterway. Thus results a net increase in capacity over the capacity of the new or the cleaned but unlined pipe.

▼

Equipment Exhibits at N.E.W.W.A. To Be Largest in Some Years

Every indication points to an exceptionally large group of equipment and material exhibits at the coming Convention of the New England Water Works Association to be held at Hotel Pennsylvania in New York City, September 22-25th, inclusive.

To date (September 10th) sixty (60) booths and ten (10) table spaces have been taken by fifty-six (56) exhibitors—a gain of roughly 20 per cent over the space and number exhibiting at N.E.W.W.A. Conventions in recent years.

An Interesting Sewer

We believe the sewer here illustrated to be the most elevated sewer known.

It was constructed across a wide ravine by the City of Conneaut, Ohio, in order to avoid—(1) an invert syphon of great expense; (2) the cost of a pumping project and the expense of its operation continuously thereafter.

After considerable thought the Engineering Department of Conneaut decided to erect the "A" frame trestle, with bents every 20 feet. Except for the 4

Elevated Sewer, Conneaut, O.

foot long channel irons at the tops of the bent, the 28 ft. lengths of 15 inch corrugated pipe (with asphalt paved invert), is self supporting. The structure which was put up by relief labor, is 32 ft. above the stream bed in the ravine and is 420 ft. long from bank to bank. The cost of all materials was less than $1,500, but that was at a time when materials and equipment were at somewhat lower prices than today.

▼

Wallace, Vice-Chairman Water Purification Division—(A Correction)

Under the report of Convention Proceedings of the Water Purification Division of A.W.W.A. in our August issue, W. C. Lawrence, Supt. of Baldwin Filters, Cleveland, O., was listed as the new Vice-Chairman of the Water Purification Division.

Mr. Lawrence has called to our attention the error and advises that the new Vice-Chairman is W. M. Wallace, Detroit's Superintendent of Filtration Plants. Well, the two cities are at least on the same water-shed (Lake Erie) and there is some excuse for getting the "drinks mixed."

AIR CONDITIONING—WHAT IT MEANS TO THE WATER UTILITY

By L. L. LEWIS and L. H. POLDERMAN*

IT is good that interest is leading to a consideration of an increasing water consumption with the growth of modern air conditioning, for, while it will offer welcome opportunities to many, it will require careful planning for the future by some. This planning will require an examination of the adequacy of supply, the capacity of pumping equipment to meet maximum demand, and the capacity of distributing systems with reference to the focal points of that demand.

While it may be possible that air conditioning has but recently become of interest to you water works operators, it is by no means a novelty. The industry is some thirty years old, having started with a small group of engineers in Buffalo. It really got under way with the disclosure of the psychrometric chart before the American Society of Mechanical Engineers in 1911 by Willis H. Carrier, who headed this small band of pioneers. During the first twenty years, application was limited almost entirely to industrial plants and, hence, few people knew of it. About ten years ago, its application began to spread to theaters, department stores, restaurants, and other buildings in which the public gather.

This second phase of development brought improvements in equipment and price reductions, and greatly broadened the market. The accomplishments of pioneers in the development of air conditioning have been truly remarkable. Unitary equipment, which can be manufactured by production methods, has brought the price level of small installations within reach of the individual who is interested solely in his comfort, or of the commercial establishment which makes an investment in air conditioning for the dividends it pays.

For example, only a few years ago, Jones would have paid $10,000 for air-conditioning his corner drug store, and would have been compelled to hire two licensed refrigerating engineers to operate his plant. Today, Jones can buy better equipment for less than $3,000 and can operate it himself with push buttons or thermostatic controls, placed in any convenient location in his store. Its initial cost and its operating cost have been reduced to a point which makes it a good investment for Jones.

Types of Air Conditioning

Without reference to those functions of relatively less importance, air conditioning may be descriptively divided into:

1. Summer air conditioning, which cools and dehumidifies.
2. Winter air conditioning which humidifies and heats.
3. Complete, or true, air conditioning, which cools, heats, dehumidifies and humidifies according to the requirements.

The equipment required to control the air in the room for complete, or summer, air conditioning can be divided into two groups, according to function:

*Chief Engineer and Western Manager, respectively, The Carrier Engineering Corporation, Newark, N. J., and Los Angeles, Calif.

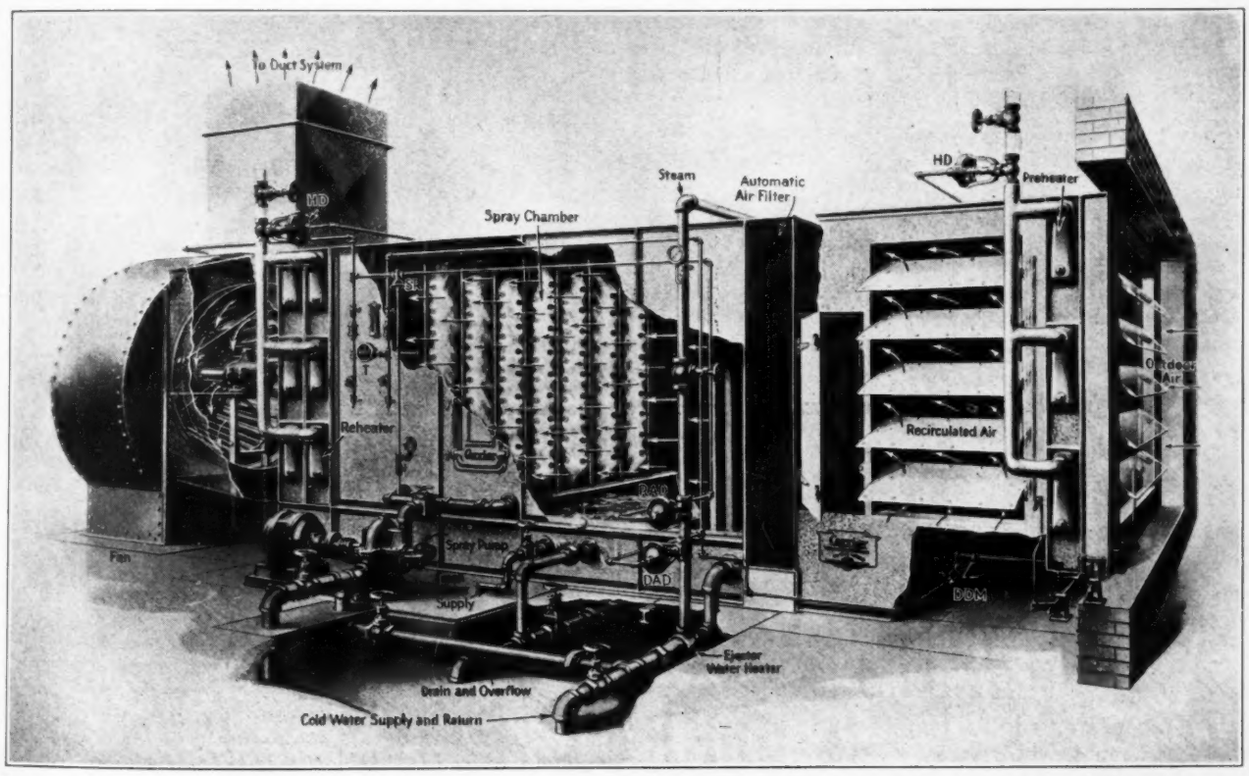


Fig. 1—A Typical Central Station Air Conditioning Unit, Showing the Spray Chamber, the Automatically Controlled Air Dampers, the Heaters, the Auxiliary Air Filters and the Centrifugal Fan.

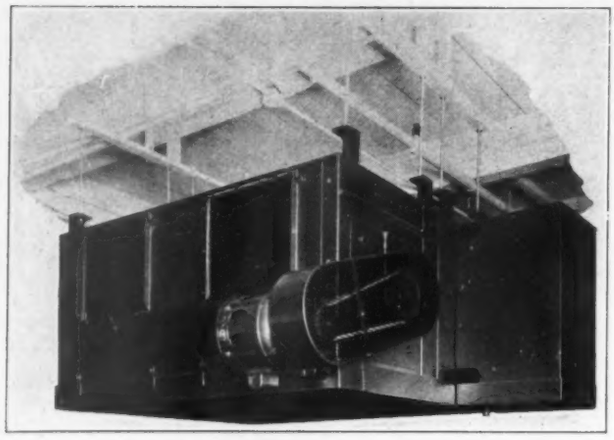


Fig. 2—Horizontal Carrier Unit Performing All of the Functions of the Central Station System.

1. Air motion and treating equipment.
2. Refrigerating equipment.

The function of the first is that of conditioning the air, which is then introduced into the room in such a manner as to meet the requirements for air conditioning.—(Figures 1 and 2.) The function of the second is to extract heat from the air and thereby perform exactly the reverse function of the boiler, which supplies a means of adding heat to the air.—(Figure 3.)

It is the refrigerating equipment which performs this second function, that imposes the main requirement for water. Some water is required for winter conditioning, but the volume required is so small that it need not be considered. The problem centers upon the water requirements of the refrigerating machine.

In its simplest elements, the commonly used compression machine consists of three parts: The cooler, in which the refrigerant absorbs heat at a low temperature; the compressor, which raises the pressure of the refrigerant so that the heat received in the cooler may be removed at a relatively high temperature; and the condenser, from which the heat carried from the cooler by the refrigerant is finally removed.

Numerous types of refrigerating machines are available utilizing a wide variety of refrigerants—ranging from water to liquid or solid chemicals. A jet of steam may, for example, serve as a compressor or gas pump. Many railroad cars are "cooled with steam." Chemicals or solutions having an affinity for water vapor may be utilized in such a manner as to produce refrigeration. Some of these machines are gluttonous in their requirements for water—others moderate.

Since a refrigerating machine—of whatever type—is only a heat pump, lifting heat from one level to a relatively higher one, the effluent heat must be carried away by some means. Usually it is carried away wholly or partly by the water you furnish. And, since the removal of heat is required during the late Spring, Summer and early Fall months, the demand for water is a seasonal one, reaching a maximum in mid-Summer.

The simplest way to get rid of this effluent heat is to buy water and pass it through the condenser to the sewer, changed in no manner other than its temperature is raised. If this were the only way to get rid of effluent heat, there might well be concern about the water demand, for it could not be met with most existing plants.

But, in certain localities prices for water have been high and, in order to broaden the market for air conditioning equipment, those who have led in its development have sought and found means of greatly reducing the water requirements of air conditioning systems. Thus, economic forces have already caused the development of equipment for the purpose of reducing air conditioning sales resistance where water prices were high or where the threat of water shortage might restrict its use.

The first stage of this development (ante-dating air conditioning) was the cooling tower—that slatted structure which will be recognized as the architectural nightmare usually seen upon the roof of the local ice plant, but which, in some modern installations, has been completely harmonized architecturally.

This cooling tower is a means of heat disposal. The water passing through it is recirculated, being pumped through the condenser where it receives heat, and then through the cooling tower where it gives off this heat to the air.

Some of the water is carried away by the wind, some of it is lost by evaporation, and that which is lost must be replenished from mains. This loss is quite small, so that the use of this cooling tower for heat disposal cuts the demand for water to about 5 per cent of what it would otherwise be.

The Economy of Evaporative Condensers

The second stage was the development of the Carrier evaporative condenser (Figure 1), in which the functions of the condenser and the cooling tower are combined. The features of water conservation have been slightly improved and the space occupied by equipment greatly reduced. This piece of equipment may be placed upon the roof of a building and appear as a small rectangle or, if it is feasible to lead air to and from it through ducts, may be tucked away in one corner of the machinery room.

Since there is no windage loss from the evaporative condenser, it requires considerably less than 5 per cent of the water which would otherwise be required. Both the tower and the evaporative condenser are instruments for the conservation of water and are fully developed practically and commercially.

Single rooms of moderate size are now being cooled with pleasingly designed equipment which requires no water at all. It is possible mechanically to do the same with larger equipment, but hardly practicable because of costliness and size. Therefore, a broad attack upon the problem of demands requires that an average be assumed for all types of refrigerating machines, as well as for varying economic balances between water temperatures and costs, and power costs.

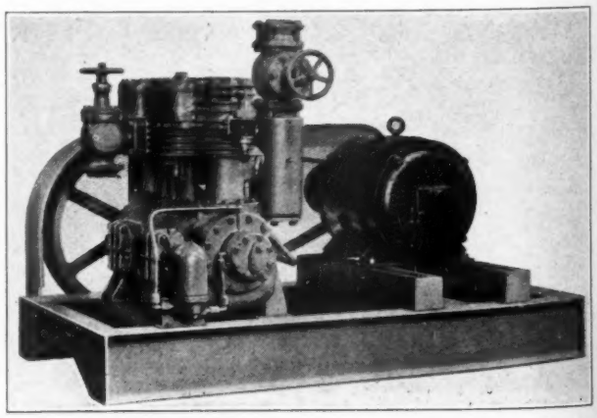


Fig. 3—Modern Type of Small Refrigerating Machine.

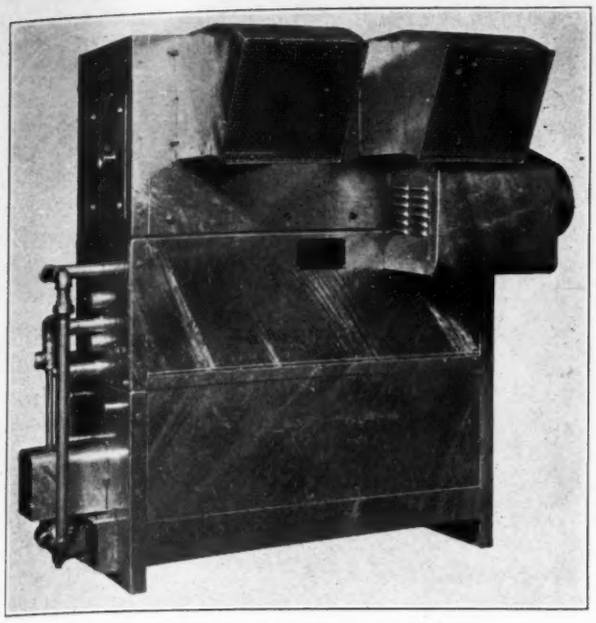


Fig. 4—Modern Evaporative Condenser

For a given power rate, cold water may throw the balance in favor of heat disposal entirely by water—warm water may do the opposite. Lower power rates may favor conservation of water—high power rates the opposite. A combination of highs of water temperature and power cost operate strongly in favor of heat disposal by evaporation. Cold water is favorable to those types which are large consumers of water, and to chemical adsorption and absorption types; warm water the reverse.

The complexity of these economic forces becomes apparent when it is realized that power for air conditioning may cost from less than 1c per kw.-hour to more than 3c; that water may cost from 45c per 1,000 cubic feet, up to $2.85—perhaps higher; that the temperature of the water coming in from mains may range in summer from 56 to 85 deg. F.; and that pocketbook limitations as to available capital may enforce the purchase of equipment which is above average in demand for water or power, or both.

Water Requirements

Two gallons per minute per ton of refrigeration produced is considered a fair figure for this average.

Table I presents a fair cross-section of the water requirements of air conditioning for various uses in a typical city.

In Table I—

1. BTU per person per hour is the average "total heat" to be dissipated.
2. Maximum Demand Gallons/Hour $\left.\begin{matrix}\\\\\end{matrix}\right\} = \frac{\text{BTU/Person}}{12000\ \text{BTU/Ton}} \times 2\ \text{GPM/Ton} \times 60\ \text{Minutes}$
3. Hours per season and load factors are from experience.

The averages obtained in Table I are carried forward into Table II, and expressed in more convenient form.

TABLE I—WATER REQUIREMENTS IN GALLONS PER PERSON PER COOLING SEASON OF 120 DAYS OF VARIOUS APPLICATIONS OF AIR CONDITIONING*

	B.t.u. per hour	Maximum demand gallons per hour	Hours of operation per season	Gallons per season at maximum demand rate	Load factor in per cent	Water requirements, gallons per season
Residence	4,000	40	2,900	116,000	30	34,800
Train	1,400	14	1,200	16,800	50	8,400
Office	4,700	47	1,200	56,400	40	22,500
Lunch Room	1,600	16	900	14,400	50	7,200
Restaurant	2,000	20	1,200	24,000	60	14,500
Drug Store	2,000	20	1,800	36,000	60	21,500
Theatre	1,000	10	1,500	15,000	30	4,500
Dept. Store	1,600	16	1,200	19,200	60	11,500
Average	2,300			37,000		15,600

*Compiled by Carrier Engineering Corporation.

Note that in the three sections of this Table are given the gallons per person:

(a) Without the use of conserving equipment (a partly discontinued practice).
(b) With present practice.
(c) With full use of conserving equipment.

Note carefully that they are *NOT* per capita consumption, but will become per capita consumption if and when a certain point of saturation, with respect to the installation of air conditioning, is reached.

It is possible to consider saturation from two points of view. The first is absurd, but should be defined in contrast with the second which is useful in this study. The first is building saturation, that inconceivable stage at which every square foot of habitable space, occupied or unoccupied, from the most magnificent to the lowliest, is air conditioned.

The second, and usable saturation, is that stage at which air conditioned space is available for 100 per cent of the population on which per capita water consumptions are based. In other words, each and every person making up the population could be in the available air conditioned spaces at the same time without overloading the equipment.

This is population saturation, and if and when it is reached the values given in Table II will then become the *PER CAPITA CONSUMPTION* of water due to air conditioning.

Therefore, if the present percentage of saturation could be determined, it would afford a factor with which the *PER PERSON* rates in Table II can be converted into *PER CAPITA* rates.

The best data known to the authors was published in the April, 1936, issue of "Heating and Ventilating." This issue tabulates the "Number and Size of Summer Air Conditioning (Cooling) Installations in Typical Cities During 1935 as Reported by Twenty-Seven Utilities to Whose Lines the Installations are Connected," as well as similar data prior to January 1st, 1936. They include "Commercial, Industrial, Theater and Recreational, Public and Institutional, and Residential" installations.

TABLE II—AVERAGE WATER REQUIREMENTS GALLONS PER PERSON*

	(1) If no evaporative condensers or cooling towers used	(2) 1935 practice which was 60% use of evaporative condensers and cooling towers	(3) If 100% evaporative condensers and cooling towers used
Per cooling season of 120 days	15,600	6,700	780
Maximum per day	300	130	15
Average per day per year of 365 days	43	18	2

*(Compiled by Carrier Engineering Corporation).

"Heating and Ventilating" states—"There is thus a definite record of nearly 300,000 horsepower and upward of 6,000 separate installations of summer air conditioning in buildings up to January 1st, 1936. The actual total is still not known but it is believed that the total number is around 8,000, and that the total horsepower exceeds 350,000."

The total horsepower of this connected load will be converted into the number of people air conditioned if it is multiplied by a factor "5," which is obtained as follows:

$$\frac{12000}{2300} \times \frac{1}{1.15} \times 1.10 = 5, \text{ in which}$$

12000 is BTU per hour per ton of refrigeration,

2300 is average BTU per hour per person—(Table I),

1.15 is average horsepower per ton including power for air motion, and

1.10 is a 10 per cent allowance for other than motor-driven refrigeration.

This conversion is carried out in Table III, which shows that, up to and including December 31st, 1935, air conditioning installations in twenty-five cities had reached 5.7 per cent of population saturation. Therefore, based on 1935 practice in the installation of cooling towers and evaporative condensers, water consumption has reached 5.7 per cent of 18 = 1.03 gallons per capita per day with a peak of 5.7 per cent of 130 = 7.4 gallons per capita on the day of maximum demand.

In Table IV is shown the number of people for whom air conditioning was installed during the year 1935. Note well that in thirty-three cities, having a combined population of 27,006,000 people, the average rate of installation in 1935 was 1.27 per cent, but varies over a very considerable range according to sales in different cities. Washington is far in the lead, due to large installations in the new federal buildings.

This 1935 factor applied to the per person rates in Table II shows that the increments of increase in 1935 were 1.27 per cent of 18 = 0.23 gallons per capita average daily use with a peak demand of 1.27 per cent of 130 = 1.65 gallons per capita.

The increment for 1936 will be considerably greater than that for 1935—perhaps doubling, and continuing to double for several consecutive years before assuming a slower rate of increase. An increase of 1 per cent of urban population saturation means a business of $75,000,000 to $100,000,000.

The Meaning of Conserving Equipment

If sales of air conditioning double in 1936, 1937 and 1938, average daily use per capita will have reached 4 gallons, with a peak demand of 30 gallons per capita if 1935 practice in the use of conserving equipment is continued. If full use of conserving equipment be started on January 1st, 1937, the respective figures would become 1.8 gallons and 13 gallons.

In all of the foregoing, average factors are used. They serve as examples for the use of a city factor for determining and predicting conditions in that particular locality and may be extended beyond 1938 if assumptions as to air conditioning sales are made.

Recorrecting factors should be applied in determining and predicting water requirements for particular localities or cities. Since a rate of 2 gallons per minute per ton of refrigeration was used as a base rate, some recorrecting factors are:

(1) Where water temperature rises to 80 deg. F. in summer—add

To Column 1 of Table II—50 per cent
To Column 2 of Table II—20 per cent
To Column 3 of Table II— 0

(2) Where water temperature does not exceed 75 deg. F. but costs as much as $1.50 per 1,000 cubic feet and power may be had for less than 1.5 cents per KWH —add

TABLE III—WATER CONSUMPTION FACTORS FOR AIR CONDITIONING SOLD UP TO AND INCLUDING 1935 IN 25 CITIES

(Data on Air Conditioning Installations by Courtesy of "Heating & Ventilating")

Year	Population	Air Conditioning Installed: Number of Plants	Air Conditioning Installed: Total Horsepower	People for Whom Air Conditioning Installed: Number	% of Pop. or Wtr. Factor
Prior to 1933	25,181,000	1,161	162,125	810,000	3.2
1933	25,181,000	799	18,939	95,000	.4
1934	25,181,000	1,568	46,874	235,000	.9
1935	25,181,000	1,994	60,110	300,000	1.2
Up to and including 1935	25,181,000	5,522	288,048	1,440,000	5.7

TABLE IV—WATER CONSUMPTION FACTORS FOR AIR CONDITIONING SOLD IN 1935 IN 33 CITIES

(Data on Air Conditioning Installations by Courtesy of "Heating & Ventilating")

City	Population	Air Conditioning Installed: Number of Plants	Air Conditioning Installed: Total Horsepower	People for Whom Air Conditioning Installed: Number	% of Pop. or Wtr. Factor
Boston	1,700,000	54	1,851	9,300	.6*
New York	6,900,000	283	11,031	55,000	.8
Newark	565,000	21	508	2,500	.4
Jersey City	317,000	7	34	170	.1
Philadelphia	1,950,000	116	4,770	24,000	1.2
Baltimore	823,000	88	2,400	12,000	1.5
Washington	487,000	159	8,634	43,000	8.8
Rochester	329,000	28	668	3,300	1.0
Buffalo	620,000	46	656	3,300	.5
Pittsburgh	832,000	95	1,423	7,100	.8
Toledo	292,000	26	490	2,500	.9
Detroit	1,760,000	90	4,395	22,000	1.3
Cincinnati	538,000	96	2,505	13,000	2.4
Indianapolis	367,000	27	1,330	6,700	1.8
Met. Chicago	3,460,000	317	5,461	27,000	.8
Milwaukee	653,000	25	441	2,200	.3
St. Louis	927,000	187	5,371	27,000	2.9
Minneapolis	484,000	35	459	2,300	.5
St. Paul	276,000	19	149	750	.1**
Denver	288,000	49	129	650	.1**
Birmingham	278,000	22	951	4,800	1.7
Louisville	308,000	35	713	3,600	1.2
New Orleans	459,000	59	2,067	10,000	2.2
Dallas	273,000	64	1,206	6,000	2.2
Houston	295,000	46	2,466	12,000	4.1
Sub-Total	25,181,000	1,994	60,108	300,170	1.2
Miami	123,000	45	930	4,700	3.8
Akron	255,000	10	49	250	.1**
Kansas City	405,000	116	3,721	19,000	4.7
Syracuse	217,000	6	211	1,000	.5†
Hartford	214,000	14	172	860	.4†
Scranton	214,000	10	138	700	.3‡
Richmond	183,000	74	1,867	9,300	5.1
Omaha	214,000	45	1,133	5,700	2.7†
Sub-Total	1,825,000	320	8,221	41,510	2.3
Total	27,006,000	2,314	68,329	341,680	1.27

*Note this is six-tenths of one per cent.
**Anything less than one-tenth of one per cent is given as .1
†Eleven months only.
‡Ten months only.

To Column 1 of Table II—30 per cent
To Column 2 of Table II—12 per cent
To Column 3 of Table II— 0

(3) Where water temperature runs 65 deg. F. or lower—discount

Column 1 of Table II—40 per cent
Column 2 of Table II—15 per cent
Column 3 of Table II— 0

Conclusions

The following conclusions seem to be warranted:

(1) That localities now without an adequate supply in seasons of drought should be singled out for 100 per cent use of water conserving equipment, unless the assurance of an additional supply can be had.

(2) That in localities having an ample supply, pumping and filtering equipment may eventually have to be increased to meet the peak demand.

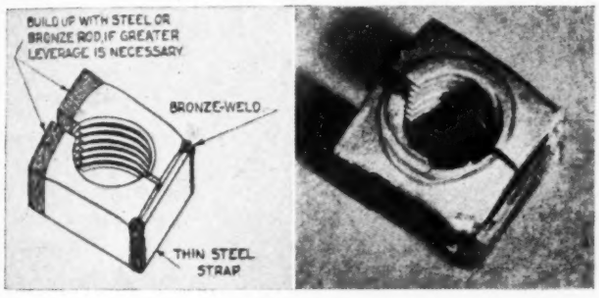
(3) That where supply and pumping equipment are ample, the concentration of air conditioning equipment in the business center may overtax mains at that focal point, or installations in the far reaches of residential districts may overtax smaller lines serving those districts.

Acknowledgment—The above paper was presented before the American Water Works Assn at Los Angeles, Calif., June 7, 1936.

A Stud Bolt Remover Easily Made

Those troublesome "frozen" stud bolts or cap screws give up easily and without becoming damaged when the "stud bolt remover" is gently applied. Here is the idea:

Select a nut, preferably one having a square head that screws on the stud easily and has the same threads as the stud. Then cut the nut in two. This can be done by



Simple But Effective Home Made Stud Bolt Remover

means of the cutting blowpipe if the operator can do a skillful job, but for this particular purpose it is better to use a hack saw. Line-up the two halves with sufficient space between them so that they are slightly further apart than in their original position.

On one side, across the cut, bronze-weld a thin piece of sheet steel to form a strap, leaving the other end of the cut on the opposite side open. The photograph shows this quite plainly.

In use, the nut is simply screwed on the stud bolt. A crescent or pipe wrench is then placed on the open split end of the nut so that the jaws grip only the front portion of the split nut. When pressure is applied the wrench jaws tighten up and force the two halves of the nut together on the screw threads. The stud is then easily removed without damage to the threads.

More leverage can be obtained by building-up the open ends of the nut to about twice the thickness of the welded side. Bronze rod or steel welding rod can be used for this.

Try out this idea. It will save time, tempers, and stud bolts. (From *"Acetylene Tips."*)

Treatment of Textile Wastes (A Review)

The Textile Foundation, Inc., now has made available a report on "Textile Waste" Treatment and Recovery."

The material presented in this 118 page booklet was collected during a thorough survey of the field of liquid textile waste disposal. The survey included an extended search of domestic and foreign literature and study of numerous unpublished research reports, consultation with the leading chemists and engineers experienced in the field, and examination of many plants now treating textile wastes All up to date information concerning textile waste disposal is summarized in the report submitted to the Textile Foundation.

Among the subjects dealt with in the report, are: stream pollution and requirements for purified effluents; textile processes and the nature of the wastes produced; reduction of liquid wastes within the mill and the recovery of by-products; the methods used for treating textile wastes and the application of these methods for the treatment of certain specific wastes; the treatment of textile wastes in combination with municipal sewage: descriptions and diagrams of plants treating straight industrial wastes, and wastes in combination with sewage; and finally the need for research in the field of textile waste disposal, with suggested problems. For the use of those who wish to go into more detail concerning certain phases of the problem, a classified bibliography of 340 references is included.

The report was prepared by John C. Geyer and William A. Perry with the cooperation of the University of North Carolina, and in counsel with Dr. H. G. Baity, Dean of Engineering.

A number of copies are available for complimentary distribution to those specially interested in problems of textile waste disposal. Requests should be addressed to the Textile Foundation, Commerce Building, Washington, D. C.

A Six-Year Program of Public Works Construction

A canvass of local government officials throughout the country to determine public construction needs for the next six years has been started by State Planning Boards under the sponsorship of the National Resources Committee, the PWA and WPA.

The sponsoring agencies hope that the program will serve to extend the practice, on the part of State and local governments, of preparing public construction budgets on a long-term rather than an annual basis. It is their belief that a six-year public works program, kept currently up to date and extended to include an additional year as each annual quota of construction is completed, should result in more effective planning and in increased economy of administration. A similar program of Federal construction is being prepared by the Works Progress Administration.

State Planning Boards are sending to local officials printed forms on which the estimated construction needs will be listed. These forms will be filled out within the next few weeks and returned to the Boards, where they will be compiled and used as the basis of a potential six-year program. Local agencies wishing to prepare such a program may secure forms from their State Planning Board.

RULES FOR SAFETY

By SIDNEY S. ANTHONY

Superintendent,
Water Department,
Augusta, Maine.

DUE to an unfortunate accident, which resulted in asphyxiation and death of three employees of the Augusta, Me., Water Department in the Fall of 1935 while attempting to work in a deep manhole, the "Rules for Safety" of the Augusta Water Department as here presented were put into effect as of October 22, 1935:

S. S. Anthony

AUGUSTA WATER DEPARTMENT RULES FOR SAFETY

Safety Equipment on Trucks—

30 ft. length of ⅜-in. rope for life-line on each truck.

Safety goggles (2 prs.) on each truck and at each grinding wheel.

Dust mask on each compressor.

Wolfe Safety Lamp, to detect explosive gas mixtures and warn of absence of sufficient oxygen to support life.

First aid kit on each truck.*

Entering Manholes—

No employe is to be allowed to enter any manhole or meter pit, for any purpose at any time, without a lifeline securely attached to him under his arms and held by another employe who is to stay on top with line secured so that it will not drop into the hole and be lost. At the first sign of distress on the part of the employe in the manhole, he is to be brought up immediately, revived, and not allowed to enter again until the manhole has been thoroughly blown out. In which case, an air hose shall be left blowing into the manhole until the work is completed. Testing equipment for sampling air will be supplied.

Grinding and Cutting—

Protective goggles shall be worn continuously while operating grinding wheels, cutting pipe or any other cutting operation where cold chisel and striking hammer are used, in the shop or outside.

Melting Kettles—

Operators of melting kettles, either lead or joint compound, shall wear goggles at all times, as well as men receiving and pouring lead or compound.

Excavations in Highways and Streets—

Set up at least two horses with signals, one on each side of work. Signals or signs to be kept fresh and bright at all times. If one becomes soiled or torn or dull it is to be discarded at once.

Work on Consumers' Premises—

Where work inside of consumers' premises is required, extreme care shall be used at all times to prevent injury or damage to private property.

Where it is necessary to disconnect piping or remove and reinstall meters, before breaking any pipe connection for any purpose, an electrical bypass (known as a "jumper") shall be connected around the section to be broken down. This jumper to be left in place until all work has been reconnected and service restored.

Meter readers shall not use boxes or other property in consumers' premises for the purpose of climbing up to reach high meters. Use ladder provided for the purpose.

When dealing with customers of the District, or any other individual, every employe shall use extreme courtesy in his attitude and conversation, shall not contradict nor argue with the customer, and shall show his numbered badge of identity upon request or upon presenting himself to request entrance to any house or other private property at any time. Badges should be worn on the outside clothing of each employe, authorized to wear one, at all times while on the job.

Refer all disputes with customers to the superintendent.

Accidents—

Full report shall be made to the superintendent immediately when any employe suffers any injury, however slight. If injury is slight, it may be dressed on the job and employe continue work until the next noon or night, when he shall report details in full to the superintendent. If serious, he must be taken to the Augusta General Hospital at once where he shall have his injury dressed and receive such treatment as is necessary. Full report to be made to the superintendent as soon as he can be reached.

Accidents to trucks or cars, whomever at fault or whatever damage caused, to be reported at once to the superintendent, together with full facts. Name of driver and owner, license number of other cars, place and time of accident, cause, and extent of damage to each car, also to be supplied.

Truck Drivers—

1. All employes driving cars or trucks belonging to the Augusta Water District will carefully observe ALL traffic laws and regulations.

2. All cars and trucks will come to a FULL STOP at every stop sign and use extreme care in proceeding past stop signs.

3. Speed of cars and trucks shall be maintained at 25 miles per hour or less within the thickly settled parts of the city and shall not be driven at excessive speeds outside the city.

4. District trucks shall not be used for transportation of persons other than district employes to and from work, nor shall they be used for personal business or errands of any sort at any time. *Exceptions*: Superintendent's car and foreman's truck.

Acknowledgment: The above "Rules of Safety" were presented by the author before a meeting of the Maine Water Utilities Association. Subsequently, they have appeared in the Journal of the Association but for the benefit of readers of WATERWORKS AND SEWERAGE are here reproduced.—EDITOR.

*(The contents of the first aid kits are: Cotton batting, 2 in. gauze and 1 in. gauze bandage, adhesive tape, 1 and 2 inch roll of bandaids, 6 gauze packs, tube of burn salve, can antiseptic powder, pair scissors, and pair tweezers, small tourniquet, package of carbon monoxide detectors, and first aid book.)

"Frozen Devil's Breath," Man's Coldest Product

To Cooper-Bessemer Corporation we are indebted for the following story—which involves one of the most novel uses of their Deisel engines for compressor operation. The story does not pertain to water or sewage but the romance in it is intriguing—in fact, it sounds like a Jules Verne or Baron Munchausen tale in relating "How the Breath of the Devil was Turned into Ice."

In about the hottest spot on earth one finds Devil's Kitchen located in California's desert on the edge of Salton Sea and almost 300 feet below sea-level. From the fuming and sputtering mud geysers comes the "Breath of the Devil"—smelly gases and steam. An enterprising and chemically minded woman—Mrs. Mary Einhart—took samples of the gas for analysis. She found it mostly carbon dioxide, the result of hot salt-water attack on deep lying limestone under high pressures. With this natural dependable source of carbon dioxide available, she raised money and built the Imperial Dry Ice Company plant which compresses, liquefies and solidifies the gas into "dry ice." From the nearby oil wells comes the cheap supply of fuel needed.

To cool automobiles traveling the desert country, Mrs. Einhart's product is a great boon. At filling stations a chunk of "dry ice" can be purchased for cooling the car in transit, as it "melts" and runs away, without so much as a damp spot left on the floor. Thus the coldest substance used by men comes from the hottest place on the American continent.

VENTILATING MANHOLES BY HAND BLOWER

By E. T. CRANCH
Manager, New Rochelle (N. Y.) Water Co.

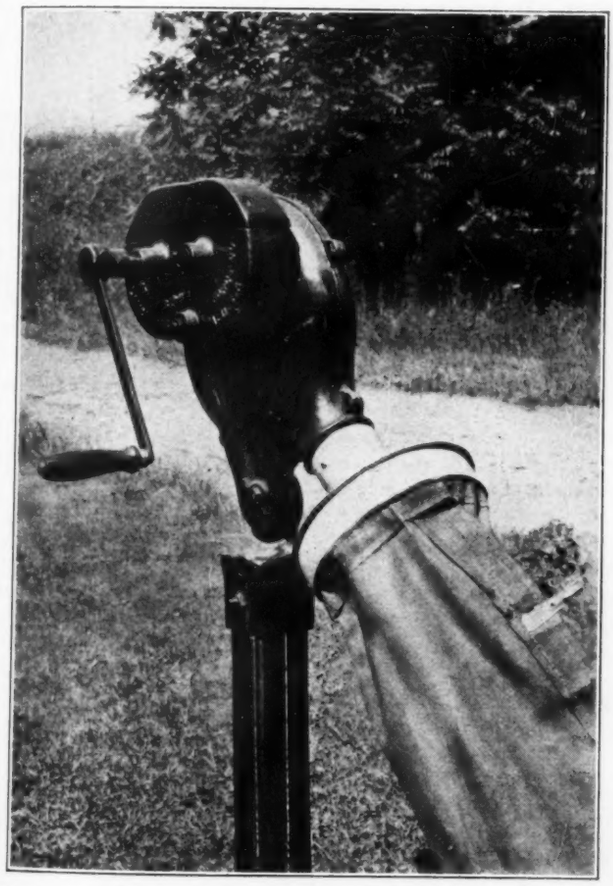
The Author

IT SEEMS appropriate at this time to discuss a piece of equipment which was developed by The New Rochelle Water Company as a direct result of the Superintendents' Session of the Convention of the New England Water Works Association held at Providence, Rhode Island, last year. At that session Mr. Sidney S. Anthony, Superintendent of the Augusta (Me.) Water District told of the tragic results of men going down into a deep, unventilated manhole.* The writer realized that this same situation might easily arise anywhere. Recollecting the discomfort he had experienced at times in going down deep into manholes, he felt that he had been extremely lucky in getting out of the manhole with only a feeling of discomfort.

On his return to New Rochelle a search was started for a suitable mechanical blower which would answer the following specifications: (1) prove reliable, (2) be easily portable, (3) prove capable of being used in any location, and (4) be inexpensive.

Blowers with an electric drive answered the first and second specifications. There are, however, places where a blower is needed where there is no electric current. This eliminated the consideration of electrically-driven blowers. Also the electrically-driven blowers were far from inexpensive.

Mr. Wright Demonstrates the Ventilating Blower to an Interested Audience.



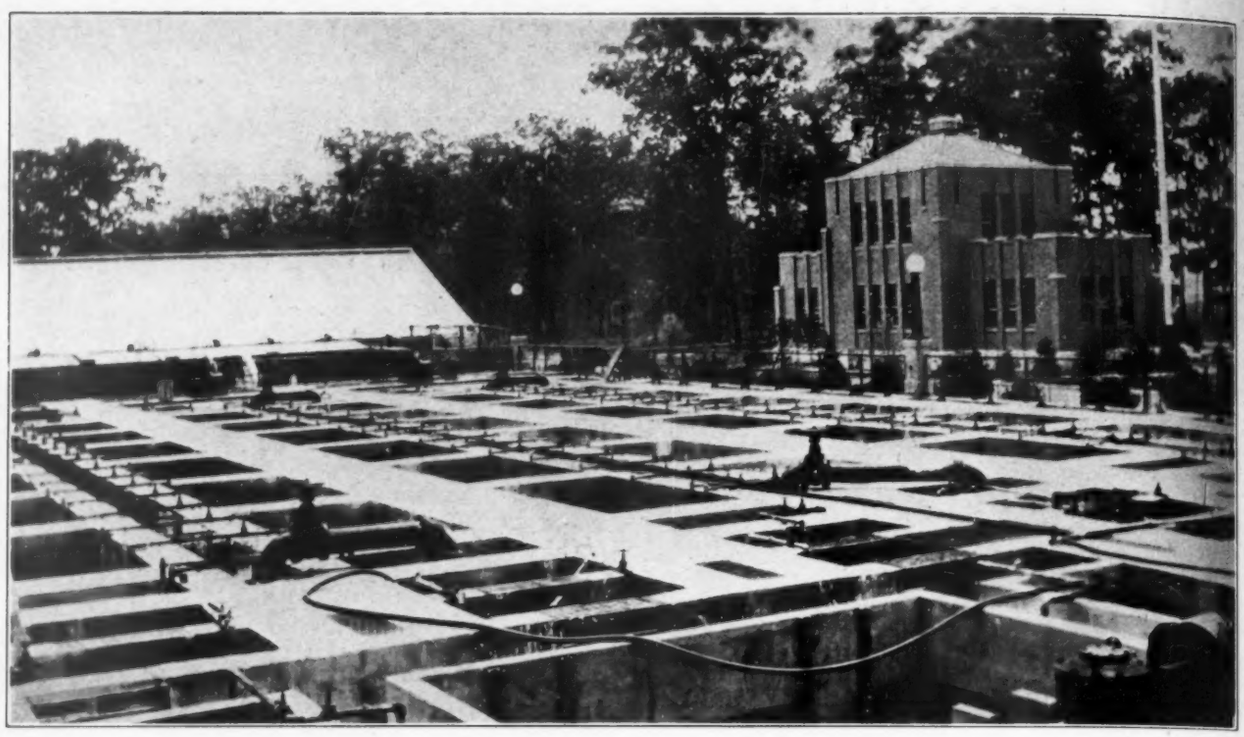
Hand-Forge Blower Converted to a Manhole Ventilator (Note the Home-Made Adapter Connecting Air Tube to Blower).

Blowers with a gasoline engine drive were considered. These seemed fairly reliable, though at times even the best gasoline engine falls down on the job when most needed. They also were reasonably portable and could be used in practically any location except that when used at night the noise of the gasoline engine might be objectionable. However none of them came within the fourth specification of being inexpensive.

Mr. Wilbur T. Wright, Jr., Storekeeper of The New Rochelle Water Company, then conceived the idea of using a hand-forge blower. We were not sure that we would get enough volume of air with this type of equipment, but the blower was very inexpensive and we thought it worth trying. So we purchased a blower and a regulation air tube. Then we had a tinsmith make an adapter to connect the blower and air tube. The whole outfit cost approximately $30 and has proven entirely satisfactory. The accompanying photographs picture this simple piece of safety equipment. One photograph also shows the ever-present youngsters, though if this had been a dangerous manhole they would not have been permitted so close to the opening.

This equipment answers all the specifications. It is reliable; easily portable; capable of being used at any location, even at night without annoyance because it is very quiet. And, furthermore, it certainly is inexpensive.

*On the preceding page is a set of "Rules for Safety" which Mr. Anthony has set up for safeguarding the workmen of the Augusta Water Department.—Editor.



The Rockville Center L. I. Plant. Blower House and Laboratories in Background. Digesters Between Aerators and Glass Covered Beds, Gas Holder Not Visible.

OPERATING AN ACTIVATED SLUDGE PLANT TO PREVENT SLUDGE BULKING

By C. GEORGE ANDERSON*
Supt., Sewage Treatment Works
Rockville Center (L. I.), N. Y.

AT THE Rockville Center Sewage Treatment Plant, we were continually troubled with sludge bulking to various degrees up to about two years ago. At that time we were attempting to carry 2,000 to 3,000 p.p.m. of solids in the mixed liquor in the aeration tanks and were returning 20 per cent of sludge by volume. A great variety of opinions as to the cause of this bulking existed and many correctives were tried —mostly with little or only partial success.

The Author

Some Observations and Trials

The possible effect of septic sewage was eliminated by prechlorination which was provided at a distant pumping station as an odor prevention measure. It has since been used to keep the sewage reaching the plant in a fresh condition.

The partially chlorinated sewage arrives at the plant with an average pH of 6.7 and after entering the first aeration tank unit increases to 6.9, which is maintained through the aeration tanks. To determine the effect of pH, lime was fed to produce various pH readings up to 8.2 for a period of three months but did not show any beneficial results. After the first year and a half the digestion tanks were well balanced and the supernatant liquor going to the crude sewage had no greater B.O.D. than a strong sewage.

Deflectors were placed on the inlet pipes to the final clarifiers to prevent sludge zone disturbances and effect better displacement, but none of the alterations seemed to be of material benefit.

The use of coagulants was tried without success.

After 3 years of operation the original aeration tubes became clogged to the extent that could not be overcome by back-washing with water and even acid baths were of no benefit. New tubes of somewhat greater porosity (80 cu. ft. per tube) were then installed and have operated for a period of 3 years without apparent clogging. It was then that we first came to appreciate the value of maintaining dissolved oxygen *at all times* in the mixed liquor of the aeration units—one factor not stressed in the many suggestions offered us.

After investigating the many possible reasons for bulking that had been suggested or described, with their respective cures, and having heard that the same trouble had been experienced at other plants, the writer thought that he would start at scratch. This, because no one seemed to have a satisfactory answer to the problem. Realization that we were working with living matter existing under conditions every bit as exacting as man or animal, I reasoned that the process

*Note: For the completeness of the Rockville Center records and Mr. Andersen's reports went the award of the New York State Sewage Works Ass'n, presented to that operator keeping the best plant operation records submitted in the competition.—Editor.

One of the Odorous Mosquito Breeding Percolation Beds—Now Abandoned Since the Advent of Mechanical Vacuum Filtration of Effluent.

could not be over-fed (over-loaded) or the organisms rushed in their work. Dissolved oxygen seemed essential and without it the effective organisms could not survive and septic effects would set up.

That there was death or septic action going on in this living matter when dissolved oxygen disappeared was proof that we did not have sufficient aeration, even when using our full capacity of blowers. The obvious answer was, therefore, either more tanks, more air, or a lessened demand for oxygen by reducing the number of organisms or organic matter requiring it. It was this reasoning that led me to find that too much sludge was being carried in the mixed liquor. The next question that had to be determined was how much sludge should be carried and how to control and regulate this quantity.

I had at one time used a centrifuge in a laboratory and had also heard that it was used in sewage work, and so proceeded to make a centrifuge out of a knuckle-jointed electrical fan by bending the blades to hold the tubes. This crude centrifuge is still in use. Samples were taken at various parts of the system and by sludge return control we varied the amount of solids maintained in the mixed liquor. From this point we gradually determined the concentration of sludge in the mixed liquor that would give the best results. This we found to be between 800 and 1000 p.p.m. (dry basis) for our conditions. The tolerance was arrived at by carefully watching the dissolved oxygen test on the mixed liquor in the aerators and by the determination of the amount of sludge, by cut and try method, that could be carried without depletion of dissolved oxygen in the mixed liquor, and simultaneously give the best effluent without bulking at any time.

Another complication with our activated sludge plant was the fact that all the sewage was pumped to the plant at markedly varying rates. By throttling the discharge valves on the pumps, so that the rate of flow to the sewage treatment works is more nearly the same throughout the day, the loading is smoothed out and the maintenance of solids balance in the aeration tanks is simplified. By frequent determinations of the solids returned from the final tanks (obtained by the centrifuge test on returned sludge and weir readings) it is possible to maintain the amount of solids in the aeration tanks within desired limits.

I have also been able to help plant operation by concentrating return sludge as much as possible. By this concentration (6 to 7 per cent solids) the volume of return was reduced to 13 or 14 per cent. Such reduction has the effect of increasing the detention period in the aeration tanks from 35 to 45 minutes, which is of considerable advantage during hours of maximum sewage flow and shortest detention.

Concentrating sludge has the further benefit that it becomes a more positive way of handling and proportioning the sludge returned to maintain the desired solids content in the aeration units. I have found that for a given speed of the sludge removal apparatus in the final clarifiers there is a limit to the rate at which sludge should be removed, no matter whether by pump or air lift. Also, that in trying to maintain a 20 per cent return by volume, there is a positive short-circuiting in the clarifier, resulting in a sludge take-off which varies greatly in solids concentration and age of sludge between point of its deposition and point of take-off from the clarifier. By slowing down on the rate of sludge withdrawal, more sludge per gallon was removed; and, furthermore, the sludge did not build up at the sides of the tank where it could become septic and then bulk. The solids in the return did not check with the known solids in the tank, indicating that the sludge was not being completely displaced. The clarifiers were then pumped out to see the exact picture of conditions, which confirmed our suspicions.

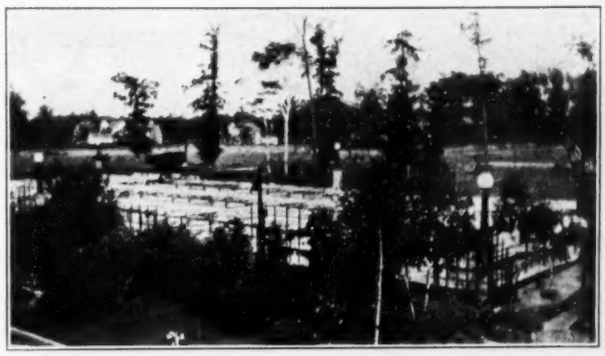
After discovering what was going on in the clarifiers air lift was discontinued and removal of sludge by pump was started. The pump line valves are regulated so that equal amounts of sludge is drawn from each clarifier and the pump discharge flows over weirs. Through a connection on the discharge line the desired quantity of excess sludge is drawn off continuously and seems to be the ideal operation. The excess sludge drawn off is then concentrated to 50 per cent of its original volume, by decantation, before delivery to the digestion tanks.

Operating Control Tests

In operating the aeration tanks and final settling tanks we utilize several control tests.

Settling Test

Sludge in the mixed liquor taken from the outlet end of the aeration tanks must settle out to 20 per cent or less, by volume, in 10 minutes. (Normally, the figure is 12 per cent.) Should sludge volume continue to run above the 20 per cent limit for as long as 24 hours, and should the sludge not be properly removed in final tanks indicating a real bulking sludge, dry hydrated-lime is added directly to the mixed liquor in the aerators to the extent of 150 p.p.m. or 600 pounds to 500,000 gallons. This acts as a positive coagulant and the system can be purged of the unsatisfactory sludge by taking out a large percentage for digestion. This drastic



Aeration Tanks, Showing Some of the Grounds Beautification and Residences Beyond.

action gives the remaining sludge a chance to more quickly revive itself instead of allowing the revival to drag out for days, during which time there will be poor purification and probable bulking. After liming, the effluent is somewhat inferior for about four hours but shortly afterwards satisfactory purification returns. We have, fortunately, not found it necessary to employ this extreme corrective measure for more than a year.

Total Solids in Mixed Liquor and Return Sludge

Total solid determinations are made daily on the returned sludge and mixed liquor. The returned sludge averages 12,000 p.p.m. total solids (dry) and the mixed liquor 900 p.p.m. These concentrations are controlled, as already described, by checking the amount of solids by centrifuge as frequently as necessary, and by weir readings on the returned sludge. We have established a weir reading for the various rates of sewage flow (pump discharge) which gives us the desired solids in the mixed liquor for the various rates of flow. With this operation, healthy sludge having good settling characteristics, can be maintained. As an extra check, at least once each shift, a rod with sample bottles attached vertically is gently lowered to the bottom of the final settling tanks to check the sludge depth at center and at the sides. This precaution is taken on account of changes in operating personnel from time to time. The minimum amount of sludge is carried in the clarifiers and this practice insures a more continuous aeration of the sludge held in the system and less opportunity for systization in the clarifiers.

Dissolved Oxygen:

Dissolved oxygen determinations are made daily (more frequently if necessary) on the mixed liquor in the aeration tanks. These show dissolved oxygen ranging from a trace in the inlet section to 3 p.p.m. in the outlet section. We have found this test to be a positive and essential check on plant operation.

B.O.D. and Total and Suspended Solids

B.O.D. and solids determinations are made daily throughout the plant.

Back Washing Diffuser Tubes:

The porous tubes are back washed at least once every two weeks, winter and summer. New tubes have been installed and this washing procedure will be continued. Tubes are back washed by connecting a hose to a T in the air pipe leading down to each aeration unit with twin tubes.

Aeration Tanks:

Aeration tanks are checked frequently for the presence of any settled material in the bottom of the tanks. This is done by using a long iron hoe. No sedimentation in the aeration tanks has been observed since the agitation of mixed liquor was increased, first by cracking the low porosity and clogged tubes and later their replacement with the more porous tubes.

Primary Settling Tanks:

The primary tanks are operated with 1 to 2 feet of crude sludge held in the hoppers at all times—no activated sludge being wasted to the crude sewage. By following this procedure, concentrated sludge can be drawn from these tanks and much undesirable liquor kept out of the digesters. The sludge drawn in a semi-septic condition is most active in breaking down the excess (thickened) activated sludge, which is still largely in an aerobic condition, so that when the two sludges are mixed while entering the digesters the mixture is more quickly acted upon by the anaerobic digesting sludge. This procedure, therefore, has the first definite advantage and to our thinking the second.

Operating Results for 1935:

A full-time chemist is employed at the plant and a large number of determinations are made throughout the day, showing in detail the functioning of all the plant processes. The operating report for 1935 as submitted to the State Department of Health required some 34 sheets.

In general the plant is operating very close to its design capacity of 2 million gallons a day; but, by operating improvements and careful control, the air consumption has been reduced to about 2 cubic feet of air per gallon. At the same time, we are happy to say. the operating efficiency has been increased.

Odors:

The fact that the plant is being operated without nuisance is proven by the new construction of high class residences directly adjacent to the plant. The plant grounds are also used as a park and some of the effluent percolation beds that have not been required since the installation of the vacuum filters (substituted for the difficult and odorous percolation pits) have been converted into a skating pond.

Summary

1. By operating the Rockville activated sludge plant as we do, sludge bulking has been eliminated by preventing conditions from setting up which we believe are primarily responsible for plant upsets and the bulking of sludges.

2. Whereas, observation of plant results will show that probably a little more aeration time might lower the suspended solids in the effluent from our secondary-clarifiers, our treatment results are considered good.

3. A plant operating at or near its capacity, such as is the Rockville Center plant, needs close attention at all hours of the day. Furthermore, the operating personnel should be of the type that have an interest in their jobs.

Acknowledgment: The above article represents a rewrite containing portions of a paper presented by the author before the New York State Sewage Works Association at Lido Beach, L. I.

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Commercial Ferric Sulphate 25 Per Cent Ferric Iron—(A Correction)

In an article in our July issue, by Wm. H. Baumgartner—"Comparative Costs of Iron Salts for Sewage and Sludge Treatment"—the author points out two errors. The first is under the paragraph discussing the "Iron Content of Salts." In describing commercial ferric sulphates the statement should read: "Commercial grades usually contain 25 per cent soluble iron of which 19 to 25 per cent in ferric iron." In the article the statement reads: ". . . of which 19 to 20 per cent is ferric iron."

The second error appears in Table II, comparing the cost of ferric-iron when purchased in various forms with that produced locally from chlorine and scrap iron, and by chlorinating ferrous sulphate (copperas). In checking the calculations the author finds the cost per cwt. of iron from chlorinated copperas should be $5.55 for coagulation and $6.37 for sludge conditioning, instead of the figures $5.30 and $6.10 which appear in Table II.

COOPERATION BETWEEN ON WATER AND FIRE DEPARTMENTS

Part I—What Water Superintendents Can Do to Enhance Fire Protection

By SHERWOOD BROCKWELL
State Fire Marshal,
Raleigh, N. C.

HAVING been Chief of the Fire Department in one of the larger cities, I believe I am qualified to know the value of a reliable water works system. I am also in a position to say to you that I have developed a "profound respect" for the water works superintendent who is charged with the important duty of maintaining an ample supply of water for a city or town; and, who has done it under conditions of municipal finances recently prevailing.

Eight years ago I appeared before the North Carolina Section of the American Water Works Association with exactly the same topic: "What the Water Works Superintendent Can Do to Cooperate With the Fire Department."

Seven years ago the North Carolina Fire College and Drill School was established and one of the first instructors to appear on the program was one of water works men who had spoken following me a year before. He came through with a wonderful and practical talk and chart demonstration of flow from different sized mains and nozzles and effectiveness of fire streams.

This was followed by actual demonstration of a fire-pumper taking suction from various sized mains and a second to show distance and height of fire streams from various sized nozzle tips. Since that time every fireman who has ever attended a session of the North Carolina Fire College and Drill School has been schooled in a manner patterned from that lecture with demonstrations. As a result there can be found on nearly every fire-pumper in North Carolina a fire stream table. Also, practically every city and town in the state has its hydrants painted to designate the diameter of the main to which they are connected. Ninety per cent of these cities and towns have standard hose couplings. That's the fireman's answer in North Carolina. Now comes the query, "What have you fellows done as Water Works Superintendents?"

Now, let's first face some facts and some responsibilities. For the past ten years, the people of North Carolina have spent more money because of fires and for protection against fires than they have for education. That is a fact which places on you water works men as much responsibility as it does on any group of firemen in the state. Now I will in part answer my question. I do not know what else you have done, but I will tell you *one* objectionable thing you have consistently countenanced or encouraged.

In a vain attempt to produce a few more dollars' revenue for your water works system, you have discouraged the proper and scientific use of water as a fire extinguishing agent and thereby allowed fire risk after fire risk to continually jeopardize the safety of your community.

I refer to service charges for private fire protection and have in mind right now a fire in which I participated less than three months ago in which a city block was threatened for more than four hours. The entire water works plant pumped at full capacity for over four hours—and, that cost a plenty. Every pumper in the Fire Department was blasting away and being worn out for over four hours. More than 444,000 gallons of water were thrown into that building, whereas, if the property had been equipped with an approved sprinkler system, probably not over three hundred gallons of water would have been used. Values saved in that city would have been more than can possibly ever hope to be derived from charges for standby fire protection for private properties. If the owners of that store, when rebuilt, desire to install the sprinkler system which every student of fire-fighting knows to be the most dependable known scheme to nip fires in the bud these owners would be called on for an extra charge for cutting the main and an annual continuous charge of at least one hundred dollars.

Getting back to the question of "What water works superintendents can do to help the Fire Department function more effectively" as long as a municipal water works is run primarily as a revenue producer there is little that you, as a superintendent, can do to help in actual fire prevention and extinguishment. This is a strong statement and I ought to be made to prove it—so, here goes.

In 1887 the city in which you are now assembled (Raleigh) installed a water works system. They already had a well organized Fire Department.. Water was placed out in the streets in mains then; and, in the intervening 48 years, we as firemen and water works superintendents have failed to bring it one inch closer to where a fire is most likely to occur. In Raleigh, as elsewhere in the state, the water is still down there in the main under the ground held back by a valve at the bottom of the hydrant—right where it was in 1890.

Now, regardless of what we as firemen or water works superintendents have done, it is still necessary for some one to discover the fire, run to a fire alarm box or telephone, and send in an alarm. The alarm must be received by the fire department, the fire fighters must mobilize; reach the scene of the fire; obtain a special wrench; remove a hydrant nipple; attach hose; stretch a line; break a coupling, attach a nozzle, convey the hose line from the street to the entrance of the building, provide an entrance (sometimes forcibly); negotiate smoke filled corridors—and, then throw water where they think it will do the most good.

Gentlemen, I have been fighting fires for a long time and up until recently never realized just how old fashioned we are. Somebody has been holding a revenue dollar above human life and it appears that we firemen and you water works men have something to think about.

One fine morning some man elected to a municipal office is going to learn that a municipally owned water works system should be a benefit to all instead of principally a revenue producer. Such a man is going to appreciate the advantage of scientific application of water on a fire through an approved ready to serve system at the potential origin of fires. He will know that better fire protection can be given by the city he represents without one cent of added cost to the city or to the property owner. Further, that in rendering this great service he will eliminate future bond issues and subsequent tax for larger and bigger water mains, pumping plants and fire engines and hose.

When such a man takes office we firemen and water works men, who have been satisfied to sit by for fifty years with the water at the bottom of a hydrant behind an airtight valve in a main out in the street; and, the superintendent who still clings to the idea of collecting the extra charge for ready to serve private fire protection will be in the position of the "foolish virgins." Gentlemen, let me remind you again that improved fire protection is still the problem of the water works men and the firemen.

Acknowledgment.—The above article consists of excerpts from a paper presented before the 1935 North Carolina School for Water Works Operators at Raleigh, North Carolina.

Part II—Some Opinions and Suggestions of a Fire Chief

By SELDEN ALLEN
Chief, Fire Department,
Brookline, Mass.

The Author

IN order to insure the value of mutual assistance between fire fighting forces in her neighboring municipalities, the Commonwealth of Massachusetts some time ago enacted a standardization law which makes it an offense for any water works or fire department to employ threads on its hose couplings and hydrant nozzles which are other than National Standard Threads. This constituted a great step in the advancement of fire-fighting facilities and outside aid, from nearby communities, in stopping or preventing major fires and conflagrations.

Based on an experience covering forty years of practical fire fighting, I wish to refer to some of the weaknesses in water works systems in so far as they affect fire fighting. Concerning some of these, I consider that the time has arrived when a definite stand should be taken by water and fire departments to correct the prominent weaknesses.

Regardless of the opinions of some, I wish to take a definite stand in opposition to dependence on the six-inch water main as a means of bringing adequate water to fire fighting equipment. Such mains have time and again proved a snare and delusion. Possibly at the time installed such a main, when new and smooth inside, may have been satisfactory in residential districts with widely separated houses. But, with the growth of housing, changes in the main size or the laying of additional mains is rarely done, if at all. Time and time again I have witnessed short comings or failure of the so-called six-inch main. Water works men will argue that, if properly grid-ironed, it will serve for the maximum load. Possibly, in theory, yes; but in actual practice, No! The story of almost every conflagration carries with it the failure of the six-inch main. So, I commend to you that you give serious consideration to the hazards of conflagration and, therefore, serious attention to the elimination of the so-called six-inch main in future developments.

The fire hydrant is primarily for the use of the fire department; but, rarely, if ever, have I found that cities and towns have any coordinated plan wherein the fire department is consulted when locations for hydrants are chosen. It is my opinion that in no other department (not even in the water department) should anyone have anything to say in selecting hydrant locations. I believe that at every street corner the driver of fire fighting apparatus should expect to find a fire hydrant. On what basis, and where, the policy and practice of locating hydrants 500 feet apart originated, I do not know, but this system has shown its weakness on many occasions.

Above all, I urge you to turn over the choice of location of hydrants to the men who will have to use them and depend upon them. I refuse to concede that anyone knows any more about where hydrants should be located than the experienced fire chief. As to hydrant maintenance, however, every phase of this rightly belongs under the water works management.

"Cooperation" between the water and fire departments should not be merely a catch-phrase. It is an economic necessity and, it is necessary for the best functioning of both departments. We confess that we, as fire-fighters, are absolutely dependent upon you who are in charge of the water works facilities. We, therefore, ask that you take us into your confidence and consider us not as extremists; but, rather as men who have a full sense of our joint responsibility in the matter of safe-guarding lives and property.

The "peak-load" which must be expected on any fire department or water works system comes with a conflagration. Both departments should be designed to meet that "load" and continuously prepared and equipped to handle it.

In closing, may I pay tribute to one of your late members, Fayette Forbes, a past-president of N. E. W. W. A., who was Superintendent of Water at Brookline, Mass., until his recent death in his 85th year of life. I have worked along side of him for 40 years, and in all that time I never pulled up to a fire hydrant in Brookline that was found to be frozen up. During his long service he always had vision and, likewise, the courage to fully state the needs of his department to the citizens of Brookline. The net result has been the most everlasting monument that can be erected to any man—the respect and confidence of those he served or worked with for so many years.

Acknowledgment.—This article has been constructed from selected portions of the stenographic record of an informal address made by the author before the New England Water Works Association on January 16, 1936.

EVALUATING TREATMENTS FOR ELIMINATING TASTE AND ODOR

By OSCAR GULLANS

Sr. Sanitary Chemist, Division of Water Purification, Chicago, Ill.*

The Author

THE treatment of surface water supplies for the elimination of tastes and odors has advanced rapidly in the past few years and there are now several methods of treatment available to the water works operator. Each of these methods has its merits in removing or preventing tastes and odors, some being more selective than others and adaptable only under certain conditions. We are confronted then with the problem of selecting the method of treatment that will be most efficient, economical, and best adapted to the specific needs. To assist in this decision, the method of testing the raw water described here is suggested as a means of determining rapidly and quite accurately the best treatment to use. The results of experiments using this method are also presented.

Realizing that the comparison of odor elimination treatments must depend on a sensitive odor test, considerable attention was given during the past year to improving the test. After a thorough study of the methods in use (1), the improved threshold test was selected as being the more sensitive and best adapted for this work. Much of this has already been published (2-3), so that only a brief summary of the odor test will be given here.

The Odor Test

The procedure for conducting the odor test, known as the threshold method, consists essentially of diluting the sample to be tested with odor-free water to the point where the odor is just detectable. The sensitivity of the test is doubled by the use of a glass nosepiece by means of which the air, after agitation with the water in a covered flask, is conducted to the nostrils with little or no dilution or contamination from the surrounding air. The odor-free water is obtained by passing the regular plant filtered water through a 48-inch bed of granular activated carbon in a glass laboratory filter at the rate of one gallon per square foot per minute. This water is then used for diluting portions of the sample to 250 c.c. in clean 500 c.c. erlenmeyer flasks fitted with glass covers. The cold odor test is conducted at a temperature of 20 to 25 deg. C., the various dilutions being thoroughly shaken and then tested with the nosepiece, starting with the odor-free blank and testing the dilutions in descending order from the highest to the lowest dilution with frequent comparisons with the blank. The hot odor threshold test is made in the same way after heating the covered flasks in a water bath to 70 deg. C.

The dilution factor is obtained by taking the denominator of the fraction expressing the amount of the original sample in the total dilution. For example, if 50 c.c. of sample were diluted to 250 c.c. with odor-free water, the amount of sample in the dilution would be 1/5 and the dilution factor would be 5. The threshold number is the dilution factor at the point where the odor is just detectable, but not detected in the next higher dilution. If an odor was detected at a dilution of 1 vol. of sample plus vols. of diluting water, but not at 1 plus 11, the amount of sample in the diluted volume containing odor would be 1/10 and the threshold number would be 10. Changes of 20 per cent in the concentration of a sample diluted with odor-free water can readily be detected by the observer with a little experience, using the above method, as long as there is a detectable odor present.

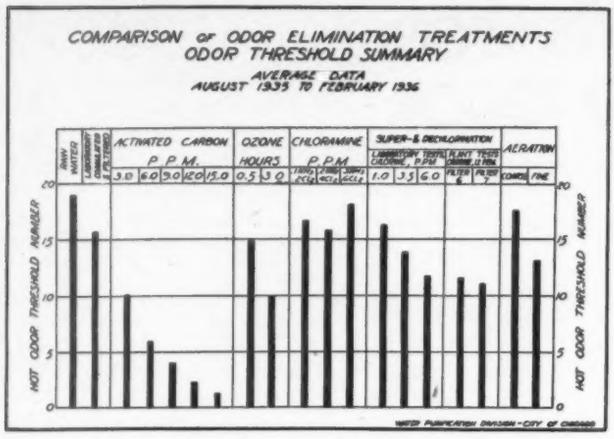
*Bureau of Engineering, Dept. of Public Works.

Method of Conducting the Tests

Five extensively used methods of treatment for odor removal were used as a basis for the experimental work. These consisted of activated carbon treatment, superchlorination and dechlorination, ozone treatment, ammonia-chlorine treatment, and aeration. The data selected cover a period during the fall and winter of 1935 on the treatment of raw Lake Michigin water when objectionable odors were present due to large numbers of micro-organisms. Most of the tests were conducted in the laboratory, except that in some of the superchlorination experiments and in all of the ozone tests the regular experimental plant equipment was used.

Laboratory Coagulation and Filtration—As a control test where the laboratory stirring equipment was used in the experiments, a sample of the raw water was coagulated with 10 p.p.m. of aluminum sulfate in two-liter beakers by stirring with the laboratory stirrer (80 r.p.m. for 15 min. The coagulated water was then allowed to settle for a short period and filtered through a clean washed cotton plug in a funnel. The odor threshold value was then determined on the filtered sample.

Activated Carbon Treatment—In conducting the carbon experiments, measured amounts of powdered activated carbon (phenol value 25) were added to the raw water in two-liter beakers and agitated with the stirring apparatus for 15 min. Each suspension was then coagulated with 10 p.p.m. of aluminum sulfate and stirred an additional 15 min., after which the suspended material was allowed to settle and the samples filtered through washed cotton plug filters. The amount of odor remaining after such treatment was determined by the threshold test. The time of contact and coagulation of the suspended carbon in the laboratory beakers was determined by comparative tests run at the same time with the regular experimental plant equipment. With equal doses of carbon and a normal operation of the plant, it was possible to determine what reaction time was necessary in the laboratory to give the same odor reduction on the same water. It would be well for every water works operator in a similar manner to calibrate his laboratory equipment so as to obtain results comparable with actual operation of his plant.



Comparison of Effectiveness of Various Odor Elimination Treatments—Lake Michigan Water

Ozone Treatment—A standard ozonating apparatus was used to treat continuously a stream of raw water at a normal rate of 600 gallons per hour. At this rate the apparatus supplied sufficient ozone to produce a color with ortho-tolidin that was equivalent to about 0.3 p.p.m. of chlorine. Bacteriological tests indicated complete removal of B. coli. The odor threshold was determined on two samples collected at the same time; one being allowed to stand 30 minutes before testing, and the other 3 hours in a covered flask. After standing 30 min. no residual ozone could be detected with ortho-tolidin and at the end of three hours the residual odor had become stabilized with little change thereafter.

Chloramine Treatment—The chloramine test was conducted in the laboratory by adding measured quantities of ammonium sulfate solution to two-liter portions of the raw water in covered flasks and allowing them to stand for 15 min. before adding the chlorine solution. Each flask was thoroughly shaken after each addition and then allowed to stand for a three hour reaction period before making the threshold test. The ratio of one part of ammonia to two parts of chlorine was selected. This selection was made based on previous experimental data which had indicated the 2 to 1 ratio the most effective combination.

Superchlorination-Dechlorination—In order to determine how much odor reduction might be obtained with superchlorination alone, two-liter portions of the raw water were treated in the laboratory with 1.0, 3.5 and 6.0 p.p.m. of chlorine and permitted to stand in covered flasks for 3 hours. Each sample was then dechlorinated with sodium thiosulfate solution and the odor threshold determined. The highest dosage of chlorine was perhaps beyond practical limits, and the odor reduction at 1.0 p.p.m. did not provide sufficient data from which to draw a conclusion. Referring to the accompanying summary graph, it seems that the odor producing compounds were quite resistant to change on contact with the amount of chlorine added.

As a second part of the super-chlorination experiment, the regular filter plant equipment was used. The raw water was treated with 12 p.p.m. of aluminum sulfate, mixed in the mixing basin for 35 min., and settled for 3.6 hours in the sedimentation basins. The chlorinator was set to apply about 1.2 p.p.m. of chlorine to the water as it entered the sedimentation basin. The filtered water for testing was collected from two of the large portable filters, each having 10 sq. ft. of surface and containing 24 inches of standard filter sand. They were operated at a rate of 2 G.P.M per sq. ft. The effluent water contained from 0.6 to 0.8 p.p.m. of chlorine, which was removed with thiosulfate before making the odor test.

Aeration—The aeration test was conducted with equipment that approximated plant aeration conditions. Part of the test was made with a ¾-inch hose attached to the raw water line and pinched together at the end with a clamp to leave an opening 1/32 inch wide and 1¼ inches long. Under sufficient pressure the water emerged from this opening first as a sheet which gradually broke up into large drops. Samples of the aerated water were collected in a large funnel placed at a distance of 10 feet from the nozzle. The water traveled along a curve of about 15 feet.

In the second part of the test, an old fashioned lawn sprinkler was adjusted to throw a spray of smaller drops of water. The travel of the water through the arc was 10 feet and the samples were collected in a large funnel as before. The spray from the lawn sprinkler was much finer than could be expected with regular plant aeration equipment, but we were interested in learning what odor reduction a more complete aeration could accomplish. The threshold test was made immediately after the collection of both samples. Because of the low cost of operation, in some cases aeration possibly is a worthy aid in reducing the amount of subsequent treatment by a more efficient method. However, the accompanying data indicate that satisfactory odor reduction could not be obtained with its use alone on this particular water.

Comparison of Odor Elimination Treatments

The summary of results of these experiments is graphically presented in the accompanying diagram. Each bar represents the average of 12 complete tests selected from the data available. In each case the entire comparison test was run in one day within a period of 7 hours, and there was little or no change in the character and odor threshold of the raw water during the period in which the tests were conducted. Where there was a lapse of an hour or more between tests or the collection of samples, additional samples of the raw water were collected and tested to detect any change. In a few instances there was some change in the raw water but not sufficient to affect the results.

The results of the actual tests, which are shown to illustrate the method of comparing the odor elimination treatments, must not be considered as an exact comparison of these treatments applicable to every water. They are correct for the particular water used in the test at the time and in the manner conducted. The data show that if the odor threshold is to be reduced to a value of 2 it is quite obvious that activated carbon treatment in some manner would probably be selected. It is also evident that a combination of superchlorination and filtration or one of the other treatments would materially reduce the amount of odor and work to be done by the carbon, so that a combination of two or more treatments may prove to be the most economical in many cases. A complete study of such application has not yet been made.

There is a difference of opinion as to how completely the odor should be removed. When the hot odor (70 deg. C.) is reduced to a threshold of 2, it is doubtful whether any odor will be detected by the consumer. It may not be essential to reduce the odor to this point, especially with an expensive treatment, but it is believed that the hot odor threshold should be as near this point as a reasonable cost for the treatment will permit.

In order to obtain a good comparison of the treatments, it is obvious that the most precise measurement

of the odor thresholds must be made, and the task would be quite difficult by any known method other than the one selected. Since the hot odors are more easily detected than the cold odors, the hot odor threshold point being generally three to five times higher than the cold, the graphs are plotted to show results obtained when employing the hot odor test.

With equipment similar to, and tests conducted in the manner described here, it is possible for any water works operator to determine the most effective treatment for elimination of objectionable odors. The comparison test is of great value where there are frequent or seasonal changes in the character of the water; and when it has been determined by test which method of treatment is the most effective, under existing conditions, further tests can be confined to a determination of the most effective dosage or rate of application of the chemicals involved.

Summary

The improved method for a sensitive odor test on water is briefly described.

The comparison of odor elimination treatments may be made on the basis of hot odor threshold determinations before and after treatment.

Procedures are given for making these tests for the comparison of powdered activated carbon, superchlorination and dechlorination, ozone, ammonia-chlorine, and aeration treatments.

The comparison of a number of treatments by the use of such tests is shown graphically.

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2. Gullans, Oscar: Procedure for Making Odor Determinations, Jour. Am. Water Works Assn., **25**, 974-981, July, 1933.

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Acknowledgment: This paper was presented before the Illinois Section of the American Water Works Association, at Evanston, Ill., April 11, 1936.

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Diesel Engines—Operation And Maintenance

By L. H. MORRISON, Consulting Engineer and Editor of *Diesel Power*. First edition, 206 pages, 6 x 9-in., clothboard covers. Published by American Technical Society, 850 E. 58th St., Chicago, Ill. Price, $2.50.

As the title suggests, the book is written for those concerned with the operation and repair of Diesel engines. The author aims to meet "the demand for a better understanding of Diesel engines and their operation, construction, and repair in general, or for those wishing to become skilled operators." The brief work is well illustrated, presenting 106 figures consisting of photographs, cross-sectional views, and charts in its 18 chapters.

The book is begun with a general discussion of the Diesel cycles of operation and their peculiarities, entering more particularly into present Diesel engine practice in the following chapter. A section is devoted to the installation of Diesel engines, giving greatest attention to the foundation. Five chapters may be thought of as dealing with general engine parts discussing designs, materials, operating troubles and their remedies with methods of procedure, etc.

There follows a chapter on the types of fuel-injection nozzles and fuel pumps for solid-injection Diesels including their operation and maintenance. The air compressor, a necessary accessory for the air-injection type of Diesel, is next considered with principles and their application. Six chapters may be grouped as dealing with those accessories necessary to the Diesel plant, as follows: The Cooling Water system—different types and their operation; Fuel and Fuel Handling Supplies—standard fuels and test standards, storage, etc.; Lubrication and Lubrication Systems—recommendations, tests, and treatment of lubricants; Exhaust Systems—types, tests, and waste heat recovery; Air Filtration—requirements and designs; and Starting Systems—the compressed-air type. A chapter is included on starting and operating procedure of a general nature with common troubles and their suggested remedies. Finally, there is found illustrated descriptions of a dozen or more of the stationary type Diesel engines found on the market with their constructional features.

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"Facts About Water Service Every Customer Should Know"

"Needlessly high bills caused by water wastage not alone are expensive to the customer, but likewise to the company. They lead to expense in verifying meter readings, in answering calls and letters, and in other ways *Worst of all, they lead to dissatisfied customers.*"

"Satisfied customers are more important than revenue secured from water wasted through leaks."

"Many difficulties and misunderstandings may be avoided if customers will follow the friendly suggestions made in this pamphlet."

Such are amongst the introductory remarks taken from the foreword of *"Facts About Water Service Every Customer Should Know"*—a neat, easy to read booklet recently sent out by Indianapolis Water Company to its customers. The booklet then brings to the reader, in readily understandable language, a discussion of "The Common Causes of Waste"; explanation of "How to Read a Water Meter" (illustrated); "Facts About Meters"; "Testing of Meters"; "How the Customer Can Test for Wastage"; "Preventing Frozen Plumbing"; "How to Properly and Safely Shut-off Water"; and, at the end, "Miscellaneous Information."

This little 3⅜ by 6⅜-inch booklet of 12 pages makes easy mailing and attracts easy reading. Slips into the pocket of the man of the house, to read on his way to work or at some other convenient time. We believe that Indianapolis Water Company, 113 Monument Circle, Indianapolis, Ind., will be glad to send a copy of this worthy little educational publication to interested water works executives.

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Industrial Improvement Taxes Toledo's Filters

Toledo, Ohio, makes it attractive for industry to buy water from the city instead of providing less satisfactory individual supplies. In a single month water sales to the 700 industrial users, served by the Municipal plant, jumped 60 per cent. R. W. "Bob" Furman, Superintendent of Filtration at Toledo for many years, and recently appointed Commissioner of Water, has found it urgent to immediately increase the capacity of Toledo's Filtration Plant to keep abreast of the constantly growing demand for water. "Flocculators" will be installed, and under way is a study of the "Jewell Sub-Surface System for increasing the capacity of existing filters* as compared with the construction of additional units.

*Recounted elsewhere in ths issue—see Report of the Meeting of Central States Section, A. W. W. A.

RAW-WATER PREPARATION vs. FILTER DESIGN

Some Observations on the "Filterability Factor," Sand Sizes, Methods of Filter Operation, and the Hazard of Predicting Plant Performance, Based on Results from Experimental Glass Tube Filters

By MARSDEN C. SMITH

Engineer, Water and Electricity, Richmond, Va.

The Author

THE rate at which water is filtered has been varied through wide limits since filtration was first used at water purification plants. There is nothing new in the statement that a very slow rate of filtration requires but mediocre, if any, chemical treatment before filtration. But many fail to realize that if large grained sand and high filtration rates are to be taken advantage of almost perfect coagulation is requisite, if a truly satisfactory effluent is to result.

Without doubt there is some optimum degree of preparation of every raw water for filtration. Whereas, a high degree of preparation will, with certainty, increase the effective plant capacity, this means less fixed charges and investment, but relatively high operating cost. On the other hand, a poorly prepared water which requires a very slow rate of filtration, necessitates a much larger plant; which results in high fixed charges but low chemical costs.

In an effort to determine the most economical operation between the limits of the old "slow" filter and the modern "super-rapid" plant, it became necessary to determine the behavior of various filters when operating with waters having different degrees of preparation.

To assist in this study, a battery of eight 2-inch glass tube experimental filters were installed. In these tubes was placed sand collected from the several plant filters (so arranged as to represent an actual cross-section of the plant filters) in order to simulate plant conditions, as nearly as possible in the operation, and study of the behavior of these small scale units.

The plant filters are each of 1078 square feet area. At the time these studies were begun, sand having an effective size of 0.41 mm, a uniformity coefficient of 1.40 and a depth of 34 inches was being used. As a result of these studies the sand in one of the plant filters and in the corresponding experimental filter was replaced with a new sand having an effective size of 0.63 mm, a uniformity coefficient of 1.51 and a depth of 25 inches. In addition, all other plant and experimental filters were so changed as to increase the effective size to 0.50 mm, change to uniformity coefficient to 1.35 and the depth reduced to 25 inches.

The experimental glass filters were operated at the same rate and with the same treated (applied) water as the corresponding plant filter. The quality of the water going onto the filters and individual filter effluents were carefully and frequently checked. The filters were operated at different rates on successive runs to include in the studies the slight differences in the characteristics of the various filters.

General Conclusions Reached

The results of these studies have led to the following opinions for the Richmond plant and the particular water dealt with—that from the James River:

1st.—The quality of water going onto the filters is the most important element in successful filtration—the better the preparation the simpler the problem of filtration.

2nd.—A factor, which for ease of expression, may be called "Filterability Factor," determines the filtration results. No chemical or physical analysis of water, known to us, permits a determination of this factor, so necessary in pre-determining filter operation results.

3rd.—The "Filterability Factor" is complex and variable, but is undoubtedly affected by turbidity intensity, type of turbidity, residual coagulant, the chemicals used as the coagulant, oxygen consumed, plankton, temperature, etc.

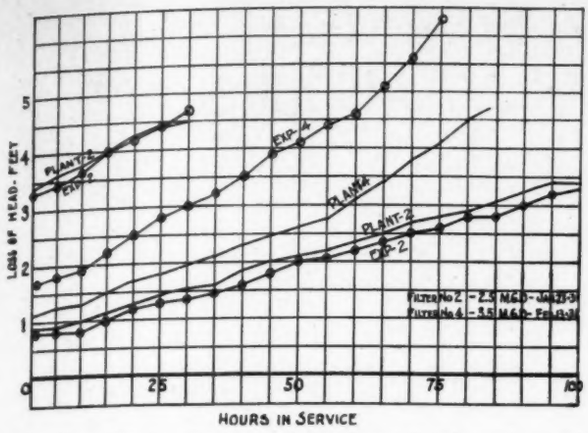
4th.—The rate of filtration affects the length of the run, the per cent of water used for washing, and the quality of the effluent. But these cannot be determined from any known analysis of the water reaching the filters. For example—a filter may actually run more hours when operating at 3½ m.g.d. than at 3 m.g.d. and at the same time have a longer run than a twin filter being operated at 4 m.g.d. The total quantity filtered, at maintained rate, may vary in the same manner. But *almost always the slower rate of filtration produces a superior effluent* when there is an observable difference. This is no doubt largely due to a different distribution in the sand of filtered out materials, which is in turn affected by the rate of filtration. In addition to the rate of filtration, we feel certain that the "Filterability Factor" also has its influence in this distribution of solids within the sand bed.

5th.—The limits of degree of preparation of waters for filtration, which will make a difference as to create a satisfactory or an unsatisfactory filter effluent, is much more narrowly defined than was formerly believed to be true.

6th.—Larger sands (certainly up to 0.65 mm effective size—the largest used in these experiments) give better results in all ways when water is properly prepared—i.e., when its "Filterability Factor" is good. But, a sand of 0.45 mm effective size (the smallest size used in these experiments) will produce a much better effluent than the 0.65 mm sand when the "Filterability Factor" is within less well defined limits.

7th.—The rate of increase at which loss of head builds up at the beginning of a run has always been found to be less than the average rate for the whole run. In other words, the loss-of-head vs. length-of-run graph will not picture a straight line relationship.

8th.—Flocculated material has never been drawn through a 25-inch depth of 0.45 mm effective size sand when the available loss of head is limited to five feet, as



Comparison Tests—Plant vs. Experimental 2-in. Glass Tube Filters at Richmond, Va.

at Richmond, where the run is terminated by reason of rate decrease. Flocculated material has been drawn through a 25-inch depth of 0.63 mm effective size sand at from two to three feet loss of head. Hence, on some runs with this coarser sand the run must be terminated by rate decrease; at other times by filter effluent quality. Again, it is the "Filterability Factor" which governs the method of operation and efficacy of filtration.

9th.—Various methods of washing the filters have been tried, including starting at a very low rate for the purpose of loosening the waste materials and this followed by a higher rate; also at lower wash rates for a relatively long time and at higher rates for a relatively short time. The most efficient washing method is difficult to accurately determine. However, we are of the opinion that the most economical method, on the whole, is to wash at the maximum permissible rate which will not result in a loss of sand into the sewer.

10th.—As the "Filterability Factor" becomes worse, or as the degree of preparation for filtration becomes less successful, the filter must be allowed to approach the "Slow Sand" type of filter operation; that is, the sand must be less thoroughly cleaned at time of wash; must be of the smaller size and the rate of filtration reduced.

11th.—The initial loss of head for different rates and for sand of different size follows closely the laws that have been generally known for some time—including restrictions of void area and shape of grains.

12th.—The *2-inch glass filters have but little value in determining plant operation.* Parallel runs, when using the same sand and the same water that passes to the plant filters, give widely different results from the plant filters, particularly in respect to the initial and the rate of increase in loss of head. This is probably due to the difficulty in controlling the rate through such a small area of sand (with probably a large effect due to the great ratio of side wall to bed area) sufficiently close for the results to be transposed into expectancy in the operation of plant units which have limited side wall effects and enormous bed areas. Further, there is an appreciable temperature rise in the glass filter when the water is cold and the filters are in a warm room. Some runs have revealed for experimental and plant filters closely parallel results but other closely checked runs, made with equal care and with the same apparatus and personnel, give widely different results.

It is rather unfortunate that at most plants the time of greatest demand for filter output coincides with the time of greatest difficulty in preparing the water for filtration. The Richmond studies of sand filtration have clearly proved the following facts: If the effluent quality at filtration plants in general, is to be maintained during these periods of high demand and difficult treatment one of the following arrangements must be provided for:

1. There must be methods and facilities available for actually increasing the degree of preparation for filtration during such periods.

2. Otherwise, a relatively large reserve area of filters, containing the most effective size of sand, must be provided if plant capacity output of a satisfactory effluent is to be assured during those periods that try the souls of even the most proficient operators.

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Sewer Gas Hazards and the Public

A number of instances have come to the attention of the Ohio State Department of Health wherein gases from sewers have entered dwellings, causing illness to the residents of such dwellings. Several investigations of these occurrences have been made by representatives of that department. In almost every instance the entrance of sewer gas into a dwelling could be attributed to the fact that some of the plumbing fixtures in the structure were not trapped and that there was no roof vent for the house sewer and plumbing fixtures.

During ordinary weather, sewer gas escapes through manholes and other natural vents and does not enter dwellings. During severe winter weather, these manholes and other gas vents become clogged with snow and ice; hence, the warm sewer gas seeks the easiest outlets and enters dwellings through untrapped plumbing fixtures. Further, the cold outside air in winter, being heavier than the sewer gas, will "spill" into sewers and displace the warmer gas upwards through untrapped basement drain outlets and plumbing fixtures.

In addition to physiological effects there is likewise the explosion hazard to consider. Sewer gas, frequently inflammable, becomes highly explosive when mixed with air (oxygen). Such a mixture entering cellars, with furnaces going, may do real damage to property if not person. All that is needed is the proper combination of circumstances, plus the correct proportion of air-gas mixtures and a fire going in the cellar.

It seems that municipalities are daily discovering new reasons for establishing Sanitary Engineering Divisions. What with dangers of plumbing cross-connections, inferior water piping in buildings, industrial cross-connections, sewer gas hazards (becoming more evident constantly), aerial pollution and the like, sanitary engineering problems are piling up on the door step of City Hall. Sooner or later their importance must be recognized by municipal authorities. The sooner the better.

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FLATS WITH BATHROOMS, 5,000 YEARS AGO.—Flats complete with bathrooms existed 5,000 years ago in the now buried cities of a lost civilization in the Indus Valley, on the Baluchistan border of India and in the Punjab, according to Dr. Ernest Mackay, author of "The Indus Civilization." One of these cities—Mohenjodaro—was a mile square. Drains made of polished brick, states the author, ran down the streets, below the surface, with manholes to enable them to be kept clear. The houses, two or three stories high, were all brick-built. The streets ran at right angles to each other, either north and south or east and west. There were no twisting, tortuous alleys such as were to be found in European mediaeval towns.

OPERATION OF THE NEW SEWAGE TREATMENT PLANT AT WILLIAMSBURG, VA.

By A. L. MEISEL
City Manager, Williamsburg, Va.

THE Williamsburg, Va., Sewage Treatment Plant, of the separate digestion-sprinkling filter type, is treating approximately 750,000 gallons of domestic sewage daily.

The Author

The crude sewage is chlorinated in order to control odors around the plant, and frequent tests are made in order to check and maintain a residual chlorine content in the primary clarifier. This prechlorination has been very effective for odor control. After prechlorination the sewage is passed through bar screens which remove any solids exceeding 1 in. in diameter. These screenings are washed and dried on the drying racks of the screen chamber, after which they are destroyed along with rubbish and garbage, in the municipal incinerator located adjacent to the sewage treatment plant.

The screened sewage then passes through a double pass grit chamber which can be used to take care of variable rates of flow. The grit chamber is followed by a Venturi meter which measures and records the quantity of sewage treated and also controls the automatic chlorinating equipment which regulates the chlorine dosage entering the raw sewage and the final effluent in proportion to the rate of flow.

After passing through the Venturi meter the sewage is settled in parallel Dorr clarifiers which are equipped with center feed radial flow equipment and sludge collecting mechanism. The average detention period in these clarifiers is approximately three hours. The average removal of settleable solids by the primary clarifiers has been about 93 per cent, based on a two hour settling period.

Filter Operation

The clarified effluent enters siphon chambers containing the low head siphons which in turn operate a revolving Dorr distributor, feeding the circular trickling filter beds. These distributors are operated on the principle of jet reaction produced by the discharge of sewage through the back of the distributor arms. The distributors are 110 ft. in diameter and the beds are 6 ft. in depth, consisting of broken granite in sizes from 1½ to 4 in.

The use of only one distributor and filter during the day has been found desirable at present flows. This scheme has proved to be an effective means of eliminating pooling on the surface of the filter as well as the control of the psychoda fly which breeds on the surface of the stone. However, both distributors are placed in operation just before the workmen leave the plant for the day, in order to take care of high rates of flow which might occur, due to storm flows after working hours. The alternate use of the filters has not in any way affected the quality of the effluent and to all appearances this scheme is actually producing a superior effluent.

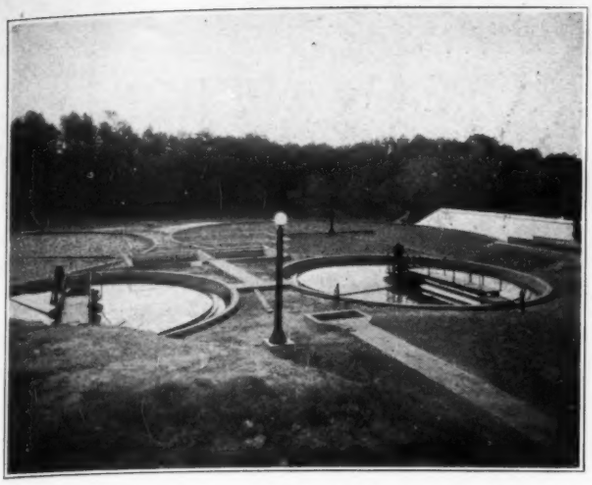
The effluent from the trickling filter is settled in deep hopper bottom final sedimentation tanks in which 1¾ hours' sedimentation period is provided. Sludge is removed from the final tank as conditions of the tank require.

Post-Chlorination

Post-chlorination of the sewage is provided by the injection of a chlorine solution into the influent to the final sedimentation tank. This long period of contract renders the effluent stable and sterile, which is evidenced by the very low bacterial counts which are made from time to time in the laboratory at the College of William and Mary. An attempt is made to maintain a trace of residual chlorine (0.05 to 0.1 ppm) in the effluent from the final sedimentation tank. An interesting sidelight on the quality of the effluent is the fact that the sewage plant operator placed two goldfish in the laboratory in a jar of the effluent from the final tank soon after the plant was placed in operation. These fish are supplied with a new quantity of the final effluent every day, and have remained apparently healthy and happy up to the present writing.

It is also important to note that soon after the plant was placed in operation that minnows began to appear

Sewage Treatment Works and Municipal Incinerator—Williamsburg, Va.
(Center) Clarifiers and Digestion Tank. (Right) Incinerator. Beyond filters are the glass-covered sludge beds on the left.



A Closer View of the Center Feed Primary Clarifiers and Filters Beyond. Sewage Treatment Plant, Williamsburg, Virginia.

in the stream below the outfall of the plant, indicating the great improvement of the creek carrying the effluent from the plant through a swamp to the James River.

Tests are made daily of the final effluent for relative stability, and these tests have shown an average stability in excess of 90 per cent at practically all seasons of the year. The overall removal of settleable solids using two hour tests have shown an average of 93 per cent through the entire plant.

Sludge Disposal

The sludge collected in the primary clarifiers and the final tank is pumped as often as necessary to the sludge digester in order to prevent the creation of septic conditions in the sedimentation tanks. The digester is heated by means of hot water coils around the inside edges of the tank to a temperature of approximately 80 degrees, which temperature is maintained at all times and registered on a recording thermometer.

The gas collected from the digester is piped to the incinerator building where it is burned in a boiler, which in turn supplies hot water for heating the digester, and the incinerator building. Also this boiler supplies hot water for sterilizing and washing approximately 300 garbage cans per day, and supplies shower baths for the attendants.

The digester is equipped with a stirring mechanism which revolves slowly and continuously in the bottom of the tank and also with scum breaking arms at the top of the tank. This equipment has been most satisfactory in producing a constant discharge of gas at a uniform rate. As the sludge is pumped to the digester, the supernatant liquor in the digester overflows to the raw sewage flume. The sludge in the digester is maintained at an approximate pH reaction of 7.0. When the reaction drops a tenth or more below this point, lime is added directly into the digester to raise the pH the required amount. No trouble has been experienced by the formation of scum or acid conditions in the digester.

Gas Production

The average production of gas has been approximately 3600 cu. ft. per day, or 0.6 cu. ft. per capita per day, and has resulted in a saving of approximately $10.00 worth of coal per week for use in heating water for sterilizing garbage cans, and for shower baths and for heating the building and the digester. When the plant was first placed in operation the gas burning boiler was fired with coal in order to produce sufficient hot water for sterilizing the cans and heating the digester. This boiler was provided with small incinerator grates in order to take care of such situations and to furnish a means of disposal of the sewage screenings when the incinerator is not in operation. The water entering the digester heating coils is automatically maintained at 140 degrees, and the average temperature of the return from the heating coils is approximately 80 degrees, which is the average temperature in the digester.

The digested sludge is drawn by gravity from the digester to the sludge drying beds which are equipped with glass covers and the sludge is disposed of by the city to parties who have use for this material as a fertilizer or soil conditioner.

The City of Williamsburg has been fortunate in having the services of a chemistry student from the College of William and Mary who has made tests several times daily of the various stages of treatment and recorded the various desirable items of information on weekly report forms containing the daily results of the tests. These report forms, after the calculations are made, are filed and a copy of each report is submitted to the State Department of Health.

A complete laboratory is provided in the incinerator building adjacent to the meter and chlorinating room. The grounds around the plant have been effectively parked and planted with trees and shrubbery, which gives the plant a neat and attractive appearance to visitors and people passing along the highway adjacent to the plant. No difficulty or objection from odors, flies or other troubles have been experienced or reported to the plant operator.

The operation of the plant entails very little expense or trouble. It is operated by the workmen attending the incinerator plant.

Acknowledgment—This paper was read before the Virginia Sewage Works Association meeting jointly with the Virginia Section of A. W. W. A. at Roanoke, Va.

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Facts About America's Big Dams

Of the innumerable dams scattered over the United States, only 66, either completed or under construction, have a maximum height of 200-ft. or more, according to an article in a recent issue of the Reclamation Era, official publication of the U. S. Bureau of Reclamation. Of this number, 52 are located in states west of the Mississippi River with 25 of the 52 listed in California.

Two dams on the Los Angeles water supply are mentioned in the list—Bouquet Canyon, height 228 ft. and Mulholland, height 200 ft.

Boulder Dam towers above all the rest with its imposing height of 727 ft. from bedrock to crest. It is 177 ft. higher than Grand Coulee Dam in Washington, second ranking structure, which, when completed, will be 550 ft. high.

Fort Peck, under construction in Montana, is by far the largest structure, 100,000,000 cubic yards of fill being required on the project. This tremendous pile is almost 10 times the next largest amount. The smallest structure contains only 43,000 cubic yards.

SCREW AND PROPELLER PUMPS MEET WITH FAVOR ON EUROPEAN WORKS

By C. H. S. TUPHOLME*
London, England

CENTRIFUGAL PUMPS, when installed for dealing with large quantities of water against comparatively low heads have the disadvantage that they must be run at such low speeds that direct drive by electric motor is in most cases uneconomical. This disadvantage has been felt more and more with the increasing adoption of the electric drive, and many attempts have been made to increase the speeds of these pumps to meet the new conditions.

In Europe, water supply and drainage works are now adopting screw and propeller pumps which have been found to comply very well with all the conditions arising in service. Intermediate between centrifugal pumps with radial impellers and axial pumps, with propeller wheels, come the screw pumps with semi-axial blade wheels. The impeller in the screw pump has no outer rim, and the blades, which are few in number, are attached to the boss and the inner rim. In the latest designs the thrust of the wheel in the axial direction is to a certain extent hydraulically balanced; the rest of the axial thrust is taken by a ball thrust-bearing acting in either direction. This bearing also keeps the shaft and the wheel in the proper position.

The propeller pump is distinguished by its simple construction. The pump is usually made with the axis vertical so that the propeller remains immersed even when the pump is not immersed. The water flows into the pump through a cast iron suction bell to the propeller, which is generally made of bronze. The guiding for the water is very simple, losses are small and the risk of choking is very slight. For technical reasons, connected with the flow, the hub of the propeller is of large diameter. This eliminates the parts of the blades where the angular velocity would be low and the conditions of flow unfavorable.

The bearing bushings for the shaft are made either of white metal, lignum vitae or rubber. The open type pump is shown in Fig. 1 and the closed type in Fig. 2. If the head against which the water has to be pumped is too great for a single-stage propeller, two propellers are fitted, one behind the other on the same shaft.

*4 North Hyde Park Mansions.

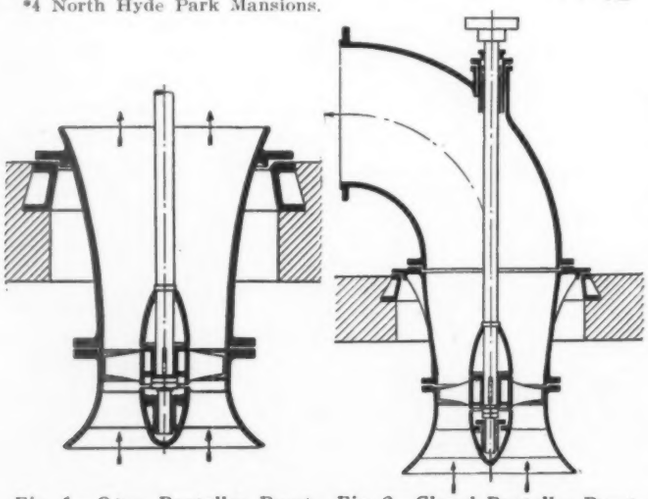

Fig. 1—Open Propeller Pump *Fig. 2—Closed Propeller Pump*

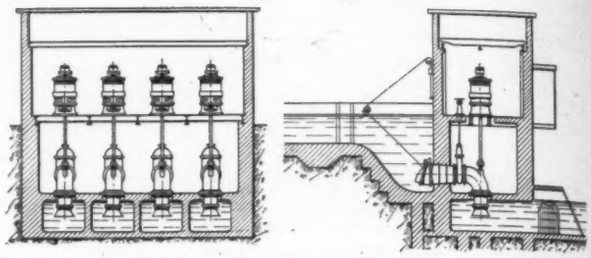

Fig. 3. Four Vertical Propeller Pumps—Capacity 18,700 g.p.m. Each against 15 ft. 6 in. Head at 83 Per Cent Efficiency

Experience shows that attendance is greatly simplified by the vertical arrangement of the pump. Thus, with the propeller immersed in water in the suction well the pumps can be started up at once without any suction being required. By adopting float-controlled switches and self-starters, the pump sets can be started and stopped automatically in accordance with the water level in the suction well. In the usual arrangement, the first pump is started when the liquid level rises to a certain point; when this pump is no longer able to cope with the inflow, a second pump automatically goes into service, and so on. The pumps are, of course, switched off successively as the liquid level falls.

No general rule can be laid down as regards the choice or installation of a propeller pump. Generally speaking, the open type pump (Fig. 1) is selected for delivering very large quantities of water against a low head, while the closed arrangement (Fig. 2) is used for higher heads or when feeding into a delivery main. In both cases the driving motors are installed above. The closed type of pump can also be directly driven by a motor mounted on the delivery bend, or the shaft may have a pulley fitted there and be driven by belt.

Efficiency curves and heads for various settings of the blades show that the propeller pump will work, for example, against a low head and deliver from 4000 to 8000 gallons per minute without the efficiency falling below 70 per cent.

The principal field found by European designers for this type of pump is in irrigation and drainage work. They are particularly suitable for such work because of their simple and robust construction, as well as the high speed at which they run and their efficiency. They have, however, also been installed for sewage and waste water pumping. They are little liable to be affected by impurities, and the wide passages between the blades means that the risk of choking is very slight.

In addition to European installations, an interesting plant is that installed in the United Provinces of India at the river Ramganga for pumping irrigation water. At this Ramganga Station, shown in Fig. 3, four vertical propeller pumps have been installed, each capable of raising 18,700 gallons per minute against a head of 15 ft. 6 in. They run at 730 r.p.m. and each requires 111 h.p. The pumps are driven through flexible couplings by vertical three-phase motors, each rated at 120 h.p. continuous. The efficiency of these pumps over a considerable working period has averaged 83 per cent.

FEDERAL AID IN RETROSPECT AND WHAT'S AHEAD*

Sanitation Works Program Has Gone Far in Correcting Vast Deficiency in Sewerage Facilities, But Much More Is Needed

MUNICIPALITIES and agencies of state governments, spending on a gradually rising scale for sanitary improvements, in 1928 reached a high point of $170,000,000 for construction and repair of sewage systems and sewage disposal plants. In 1933, however, spending for this purpose had fallen to $48,000,000 because of the sad state of finances of public bodies. Cities, counties and even states found they could not raise the money to spend on this vitally important but under-appreciated item of decency and health. Under such circumstances the aid of a paternalistic government seemed logical and that it was so proof is available.

With the coming of the Federal Emergency Relief Administration, expenditures for sewerage facilities was increased to $115,000,000 in 1935, which was almost the amount expended in 1929. Engineers of the Works Progress Administration (hereafter referred to under its well known initials—W.P.A.) have calculated that the present sewer and sewage disposal plant deficiency for the whole country is still about $1,400,000,000, which can and should be taken care of in six years by expenditure of about $233,000,000 a year. This amount, it is estimated, would make up for the lack of construction during the years from 1928 to 1934 inclusive, and would also take care of current needs in the way of new construction and repairs.

W.P.A. statistics show that since the start of the Work Program, a total of 5,384 sewage disposal projects have been selected for operation and that when they are completed, the sum of $101,027,258 will have been expended in the forty-eight states and the District of Columbia. This building is exclusive of that done under other Government agencies and by agencies of state governments for their own account, and has gone far toward paving the way, at least, toward clearing up the $1,400,000,000 sewer construction deficiency which still exists.

Included in the present program, are projects of every kind, ranging from the badly needed repair of and extensions to existing systems, to the building of complete new systems and disposal plants.

In all parts of the country, public health officials have taken the opportunity to secure long recommended improvements insisting that sewage disposal projects be put to the fore-front as amongst the most worthy projects. Because, in most cases, labor was the largest element of cost involved, the federal relief agencies gave sewerage projects early approval; and, from the accompanying statistics it is plain that W.P.A. has contributed much to put an end to the practice of municipalities dumping sewage into streams and expecting communities or property owners below to look out for themselves.

Communities which got the benefit of sewage disposal projects can congratulate themselves that they took advantage of an exceptional opportunity to secure something in the way of a permanent improvement, and at a most reasonable cost, that will require little expenditure for upkeep.

Accomplishment by States

While in nearly all cases, sponsors of sewage disposal projects were required to make contributions in the way of furnishing materials, local considerations determined the extent of the required contributions. In Arizona, for example, the total cost of the projects was only $10,329 and of this amount the state agencies contributed $6,122; the Federal Government $4,207. This might be contrasted with California where the sponsors contributed only $1,048,348, whereas, the Government added $6,843,784 to make a total of $7,892,132.

In one case, that of New York City, the sponsor contributed nothing to projects for which the Government spent $11,867,397. However, upstate municipalities in New York contributed $5,214,541, and the Government $8,802,922 to make a total of $14,017,463 for that section where unemployment and financial distress was not so acute. The total of projects for the State of New York was $25,884,860.

The total contributed by all sponsors in the 48 states and the District of Columbia was $21,187,796 and to this the Government added $79,839,462 to make the total of $101,027,258. Thus, on the average sponsors contributed only 20.9 per cent of the cost of all projects—a figure materially lower than usually assumed.

Total payrolls for the projects were estimated at $63,494,659 and the amount spent for materials and administrative cost was $37,532,599. The average wage for labor was 43 cents per hour.

The accompanying table shows the number of projects in each state, contributions of the sponsors, and contributions of the Federal Government:

SEWER PROJECTS SELECTED FOR OPERATION
(Through April 15, 1936)

States	Number of Projects	Total Approved Cost	W.P.A. Contribution	Sponsor's Contribution
Alabama	20	$ 465,905	$ 339,625	$ 126,280
Arizona	3	10,329	4,207	6,122
Arkansas	33	210,872	170,431	40,441
California	180	7,892,132	6,843,784	1,048,348
Colorado	40	607,562	515,190	92,372
Connecticut	155	2,033,055	1,565,852	467,203
Delaware	8	213,961	170,014	43,947
District of Columbia	2	498,106	307,515	190,591
Florida	41	777,878	562,560	215,318
Georgia	41	3,225,672	1,514,504	1,711,168
Idaho	13	171,242	89,686	81,556
Illinois	136	5,948,344	5,512,730	435,614
Indiana	122	1,557,930	994,587	563,343
Iowa	77	1,359,414	1,253,311	106,103
Kansas	43	472,218	386,196	86,022
Kentucky	103	1,244,097	1,011,849	232,248
Louisiana	20	615,552	430,417	185,135
Maine	45	532,274	401,166	131,108
Maryland	40	1,228,999	1,035,045	193,954
Massachusetts	527	4,902,079	3,322,904	1,579,175
Michigan	240	5,086,113	4,199,101	887,012
Minnesota	127	1,056,192	804,168	252,024
Mississippi	38	414,914	362,874	52,040
Missouri	57	2,298,738	1,734,061	564,677
Montana	14	236,422	199,921	36,501
Nebraska	57	579,271	485,948	93,323
Nevada	2	14,930	11,633	3,297
New Hampshire	70	819,400	549,505	269,895
New Jersey	237	2,839,346	2,286,003	553,343
New Mexico	16	130,102	95,189	34,913
New York State	674	14,017,463	8,802,922	5,214,541
New York City	7	11,867,397	11,867,397	.....
North Carolina	74	788,760	528,666	260,094
North Dakota	32	175,076	131,246	43,830
Ohio	849	8,497,419	7,022,847	1,474,572
Oklahoma	59	1,205,401	979,248	226,153
Oregon	14	99,136	78,726	20,410
Pennsylvania	433	7,049,649	5,420,203	1,629,446
Rhode Island	32	701,541	469,131	232,410
South Carolina	23	174,713	122,584	52,129
South Dakota	26	188,197	135,303	52,894
Tennessee	35	329,247	227,008	102,239
Texas	120	1,694,630	1,344,825	349,805
Utah	32	358,657	278,288	80,369
Vermont	16	175,723	103,959	71,764
Virginia	67	583,791	459,073	124,718
Washington	45	1,128,747	896,135	232,612
West Virginia	130	1,639,021	1,525,881	113,140
Wisconsin	204	2,852,313	2,256,888	595,425
Wyoming	5	57,328	29,156	28,172
The United States.	5,384	$101,027,258	$79,839,462	$21,187,796

*For the material presented in this article we are indebted to A. W. von Struve, Chief of Periodicals Division, Works Progress Administration, Washington, D. C.—Ed.

COMPARATIVE FIRE-PROTECTION VALUE OF DISTRIBUTION SYSTEMS

By CHARLES H. CAPEN, JR.*
West Orange, N. J.

TO the average layman, the statement that every water bill involves a certain payment for fire insurance would ordinarily seem far fetched. He may usually be convinced, however, by the explanation that water rates are based on the cost of doing business and that a considerable part of the construction and maintenance cost of a water supply is directly attributable to the large size of mains necessary for adequate fire protection.

Fire insurance rates are to a large extent determined by the National Board of Fire Underwriters and the various other agencies operating in conjunction with them. In order to place the rates on a well ordered and uniform basis the National Board adopted a Standard Schedule (1) on December 14, 1916. It is the practice of the Board to make periodic surveys of all cities in the country and to establish insurance rates based on the actual measured value of fire protection as determined by applying the results of the survey to the standard schedule.

In the introduction to the book containing the schedule, it is shown that of the total points by which a town may be scored, the portions are allotted as follows: water supply, 34 per cent; fire department, 30 per cent; remainder, 36 per cent, divided between fire alarm, police, building laws, hazards and structural conditions. The section devoted to water supply is divided into 32 separate primary headings, of which 15 refer directly or indirectly to mains and hydrants.

A particularly poignant statement from the schedule is as follows: "In grading the adequacy of the water supply two features are considered:

1st. The ability to deliver fire flow at any pressure down to 20 pounds . . . and having all hydrants provided with at least one steamer outlet; this is a measure of the ultimate capacity of the system to maintain supply of some sort under conflagration conditions and with the system in full operation. . . .

2nd. The ability to deliver this fire flow or a part thereof at pressures permitting streams direct from hydrants."

Thus it may be seen that the real measure of the fire protection service afforded by any water distribution system is the actual ability of that system to deliver sufficient water at any and all times. A very clear and concise discussion of many phases of the subject has been given by Goldsmith (2) of the National Board of Fire Underwriters.

To obtain the data necessary to permit grading of any city a field survey of considerable extent is required. Among other things, actual pressure and flow measurements at various hydrants on the distribution system are required. The records so obtained are not ordinarily available to the public except as published in the reports of the National Board. Even then considerable study is required to understand the true significance of the results. It is not intended to criticize the invaluable service that has been rendered by the National Board of Fire Underwriters, but rather it is desired to point out that the proper correlation of the data is a task of no mean proportion.

An appreciation of the value of a properly designed and operated water system, insofar as fire protection is concerned, may be obtained by reading contributions on this subject by Pirnie (3) and Duff (4).

Classification of Distribution Systems

The writer has had occasion to attempt to classify the relative values of many distribution systems in northeastern New Jersey and has already given in an earlier issue of WATER WORKS AND SEWERAGE (5) a summary of some of the findings with respect to the cost of fire protection service insofar as it relates to distribution systems. It was pointed out therein that in more than 100 municipalities in the area in question, such service is paid for on the basis of the inch-foot main size and hydrant service charge. While generally admitted as the best method in vogue for charging for such service, it omits consideration of the vital fact that the carrying capacity of any pipe varies almost as the square of the diameter instead of the linear dimension of diameter. It might be reasonable to suppose therefore that a unit which could be termed "Inch-Square-Foot" would be more equitable as a basis on which to charge for this service. (In the remainder of this discussion the letters "I.F." will be used to designate Inch-Foot units and "I.S.F." to designate the Inch-Square-Foot units.)

It is important to realize that the approximate methods of classification hereinafter described do not include any correction for such items as age or condition of pipe, partially or wholly closed valves, proper location of mains and other details that directly affect the fire flows. Other things being equal, however, there should be some relation between the actual value of the service rendered and the cost of the service. The following discussion will serve to show some of the relationships which exist between the factors of "I.F.," "I.S.F." and hydrants and the population of various municipalities, together with conclusions as to the equity of charging for the service on this basis.

Data Used and Procedure

From the periodic reports of the National Board of Fire Underwriters and of the Schedule Rating Bureau, the following data were taken for each of more than one hundred municipalities: diameter and length of distribution mains, number of hydrants, population* and area. Using these data, the I.F. and I.S.F. values were computed. On account of the wide range in values, any curves plotted to show the relationship between I.F. or I.S.F. values and population, require logarithmic scales having wide ranges for both ordinates. For this reason the I.F. and I.S.F. figures were reduced to a per capita basis and these units were used throughout the studies.

Since both the I.F. charge and the value of fire-protection are based primarily on distribution mains, a common footing of comparison is immediately afforded.

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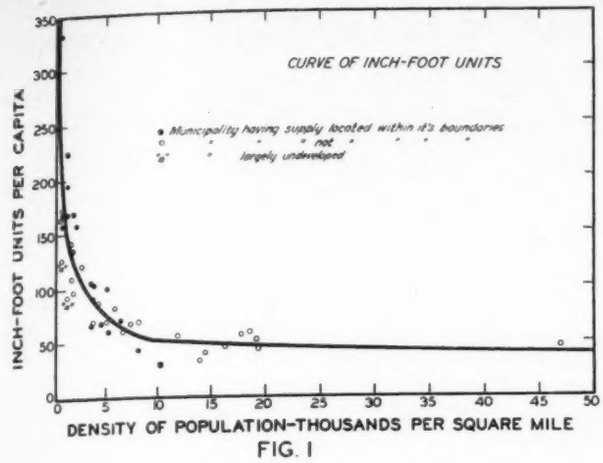
*Note: Estimates of population, as of date of Underwriters' reports, were made on the basis of the 1930 census so as to give uniform comparisons.


CURVE OF INCH-FOOT UNITS
• Municipality having supply located within it's boundaries
○ " " " not " " " "
"a" " " largely undeveloped
INCH-FOOT UNITS PER CAPITA
DENSITY OF POPULATION-THOUSANDS PER SQUARE MILE
FIG. 1

The line of demarcation between transmission and distribution mains is not always clear, however, and in a few instances some arbitrary exceptions have been made to the classification established in the reports of the National Board and the Schedule Rating Bureau, merely for the purpose of establishing a uniform basis of comparison.

For the main study, a group of more than forty municipalities owning their own distribution system were selected merely for the completeness of data, without regard to any other classification. It was hoped that a comparison could be made against municipalities served by private water companies and all the data for more than seventy such municipalities were compiled. It was later found that where a company serves a large number of municipalities, the system of mains becomes so involved that a reasonable separation of transmission and distribution mains would not be possible without a great deal of detailed study. Even then the results would not be strictly comparable and for these reasons have been omitted notwithstanding the fact that some moderately comparable figures were obtained. Another important factor in distorting figures for these privately owned works is that many of the municipalities so supplied are only partially developed and any estimate of the density of population immediately introduces a variable of such magnitude that the results are of questionable value.

Curves Drawn

In presenting average or normal curves, the writer has drawn on a general knowledge of all these systems to permit a greater or less consideration of any plotted point according to its marked weight. Therefore the curves presented may not always appear to be consistent with the points plotted.

Using logarithmic scales for population and arithmetic scales for I.F. and I.S.F., points were plotted and approximate curves were drawn. The deviations from the mean, some of which are not readily explainable, were of considerable magnitude and the curves have therefore not been presented. They indicated, however, that the I.F. units per capita decrease continuously as population increases but that the I.S.F. units per capita decrease until a certain population is reached, after which an increase occurs. This suggests that when a fairly definite population is attained by a municipality, necessity requires the use of larger main feeders and hence rapidly increases the I.S.F. units, both total and per capita. A study of the data tends to verify this conclusion.

Since many problems related to population and its growth are studied on a basis of density of population, the unit of population density per square mile was then computed for each municipality. This permitted a comparison of data for municipalities varying widely in area and population and at the same time eliminated logarithmic scales.

Inasmuch as the I.F. charge is in widespread use, a curve to show the relationship of these units per capita to density of population was first plotted, see Figure 1. The range of this curve is so great that accurate plotting or comparison is not easy and for that reason Figure 2 has been drawn to a larger scale, showing the more important portion of the same curve. The surprising part of the curve is not the deviation of the points plotted but rather that a sufficient degree of uniformity exists to permit drawing so reasonable a curve. The points marked "a" indicate municipalities of large area that are only developed to a small degree.

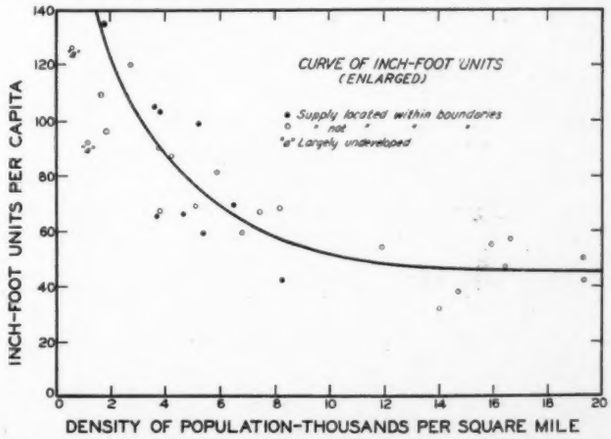
The I.S.F. units do not follow as orderly a variation as the I.F. units, but, as shown in Figure 3, an approximate curve may be drawn. This curve brings out the effect of the larger diameter distribution mains that are required after a certain density of population has been reached.

The solid black dots represent municipalities whose source of supply lies wholly within the municipal boundary lines while the hollow circles are for those where the opposite is true. While it is by no means entirely apparent from the curves, these studies indicated that for supplies located within the boundary lines, advantage has usually been taken of the situation to use large mains both for transmission and distribution, thereby increasing both I.F. and I.S.F. units. It is apparent from the curves that in a fairly densely populated territory such as this, the great majority of supplies have been brought from outside of municipal boundaries in order to obtain water not subjected to heavy pollution.

The fixed charge on hydrants, either with or without an I.F. charge, is in quite common use and for this reason Figure 4 has been drawn showing the relationship of hydrants per thousand population to the density of population.

Equity of Inch-Foot Plus Fixed Hydrant Charge

An analysis of the fire protection revenue received by private companies in this territory, indicates that the fixed hydrant charge (usually about $10 per annum) amounts to about 15 per cent of the total of this so-called municipal revenue. The balance is largely allocated to the I.F. charge. No consideration is given to the population served except where some companies


CURVE OF INCH-FOOT UNITS
(ENLARGED)
• Supply located within boundaries
○ " not " " " "
"a" Largely undeveloped
INCH-FOOT UNITS PER CAPITA
DENSITY OF POPULATION-THOUSANDS PER SQUARE MILE
FIG. 2

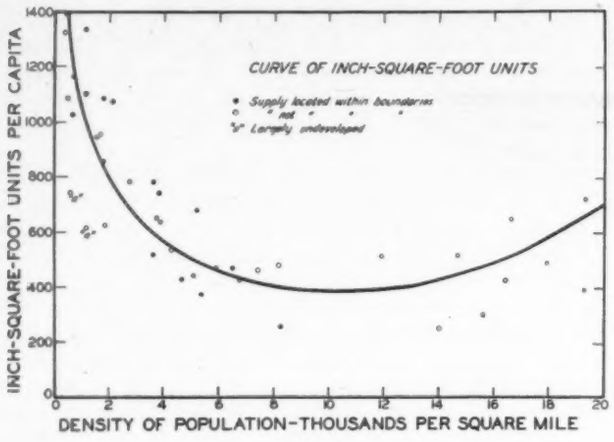


FIG 3

charge for certain transmission mains on an I.F. basis and allocate those charges to each municipality served, in the proportion that its population bears to the total population.

The natural question that arises is "What relation do the present charges for fire protection service bear to the value received?" This naturally requires a study of the I.F. method and its relation to fire protection. The writer has already briefly described (5) the derivation of the charge.

The formula for fire flows required by the National Board is:

$$G = 1{,}020\ \sqrt{P}\ (1 - .01\ \sqrt{P}) \quad \ldots\ldots (A)$$

where G is the gallons per minute and P is the population in thousands. Reducing this to a per capita basis, the formula becomes

$$\text{Gal. per capita} = \frac{1.02}{\sqrt{P}} - .0102 \quad \ldots\ldots (B)$$

(For comparisons of the type used hereafter in the text, the last term of the equation may be neglected.) It becomes apparent that while the total flow requirements increase with population the per capita flow decreases as population increases. Thus a greater burden per capita for fire protection is placed on those residing in small communities.

From the curve in Figure 2, it may be found that in the more common range of population densities, i.e., from 2,000 to 15,000 per square mile, an approximate formula may be written as follows:

$$\text{I.F. per capita} = \frac{170}{\sqrt{D}} \quad \ldots\ldots\ldots (C)$$

where D is the density of population in thousands per square mile. Equations (B) and (C) show a similarity in form even though they are not strictly comparable in every respect since (B) deals with total population while (C) deals with density of population.

For any given municipality, however,

$$D = \frac{\text{Population in thousands}}{\text{Area}} \text{ or } \frac{P}{A}$$

and since A is constant, $\frac{1}{A}$ may be represented by C, hence $D = C\ P$ or $\sqrt{D} = C_1\ \sqrt{P}$. Then, since the cost per capita (neglecting for the moment, consideration of the fixed hydrant charge), is a constant times the number of I.F. units per capita, we may write for any given municipality:

$$\text{Cost of fire service per capita} = k\ \frac{170}{C_1\ \sqrt{P}} \text{ or } \frac{C_2}{\sqrt{P}} \quad (D)$$

On this basis, Equations (D) and (B) are directly comparable, which permits an expression of the relation of cost of service to required fire flow as follows:

$$\frac{\text{Cost of fire service per capita}}{\text{Required fire flow per capita}} \quad \frac{\text{Equation (D)}}{\text{Equation (B)}}$$

Omitting the fixed term in Equation (B) gives the result:

$$\frac{\text{Cost of fire service per capita}}{\text{Required fire flow per capita}} = C_3 \text{ (a constant)} \quad (E)$$

Equation (E) would indicate that the cost is in direct proportion to the required fire flow and thereby a strong argument in favor of the I.F. charge is presented. Referring now to Figure 4, the curve drawn may be represented by the equation:

$$\text{Hydrants per thousand population} = \frac{46.6}{\sqrt{D}} \quad \ldots (F)$$

By the same method as employed above, it may then be shown that the cost of hydrant service is in direct proportion to the required fire flow. Therefore, insofar as water supply alone is concerned, the conclusion is reached that the I.F. and fixed hydrant charges constitute a just and reasonable method of levying the cost of fire protection.

The equity in all respects would be fully established if fire insurance rates were uniform for all municipalities meeting the requirements of equations (B) and (C). Such is far from the case, however. A study of the rates existing in the various municipalities included in this discussion, indicates very clearly that the smaller (in population) and less densely populated ones pay higher insurance rates than do the others. Thus the suburban or rural resident not only has to be provided with a higher per capita fire flow, but he also pays a higher per capita rate for water supply and for insurance.

For Figures 2, 3, and 4, prints of the curves were obtained and the insurance ratings (in letters) were written in opposite the plotted points. While in the case of the I.F. and hydrants (Figures 2 and 4), the results were reasonably consistent, the real proof of the value of the curves appeared in the study of Figure 3. Of 41 municipalities represented, 21 fall above the curve and 20 below. Of the 21 above, 15 showed ratings normal to the class in which they naturally fall, 4 showed ratings above the normal and only 2 showed ratings below the normal. Of the 20 below the curve, 6 showed

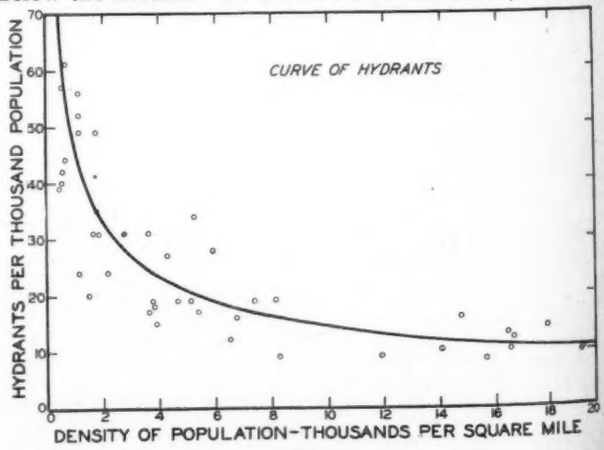


FIG. 4

ratings normal to the class in which they naturally fall, 2 showed ratings above the normal and 12 showed ratings below the normal. Of the several points showing extreme deviations below the curve, all were below the normal class rating. The natural conclusion is that the I.S.F. units form a very reasonable indication of the fire-protection value of the distribution system.

Comparison with Private Supplies

The same procedure as already outlined was carried through for about seventy municipalities served by private water companies but as mentioned before the results were not so readily comparable and are not presented for that reason. In general, however, it may be said that the publically owned systems are somewhat more liberally provided with mains and hydrants than the privately owned systems, in spite of the fact that practically all the latter receive direct compensation for the service while most of the former do not.

Use of Curves

While it is fully recognized that various sections of the country are not entirely susceptible of direct comparison, nevertheless a certain relationship should exist and a few minutes spent in computation will permit comparing the I.S.F. units of any distribution system with the average shown here. Frequently comparisons with neighboring or similar systems are desired and this method affords a quick and simple method for so doing.

Suggested Method of Establishing Charges

Without desiring to upset existing methods, the writer feels nevertheless that attention should be drawn to the elements that might well enter into the allocation of the portion of costs of water works chargeable to fire protection. These include the I.S.F. units (as opposed to I.F. units), hydrants and population. A detailed discussion need not be given at this time and each case should be considered on its individual merits.

A suggested division would be as follows:

Item	Per cent of total charge allocated to item
I.S.F. units	60
Hydrants	15
Population	25
	100

It seems obvious that charges by private companies, serving several municipalities, may be more equitably distributed by the proposed method. Where municipally owned supplies already do or can charge for fire protection service, such a method would establish a rate under which a reasonably increased revenue would accrue as the municipality develops; with perhaps a decennial adjustment of rates at the time of each Federal census.

In closing it may be said that last, but not least, the prospect of adequate return for money invested should urge all water works officials, whether private or municipal, to provide the utmost in carrying capacity and fire protection with a probable decrease in insurance rates that will ultimately far more than offset the cost of an improvement in distribution mains.

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3. Pirnie, Malcolm; Value of an Adequate Supply of Water for Fire Fighting, Jour. A. W. W. A., 26:9, 1152, September, 1934.
4. Duff, Robert A.; Distribution System Design and Upkeep, Jour. A. W. W. A., 26:9, 1178, September, 1934.
5. Capen, Chas. H., Jr.; Fire Protection Charges for Municipally Owned Water Works. WATER WORKS AND SEWERAGE, 81:9, 324, September, 1934.

ASSOCIATION MEETINGS SCHEDULED:

SEPT. 14-17—SANTA MONICA, CALIF.
California Sewage Works Association. Annual Convention. F. D. Bowlus, 202 Law Bldg., Los Angeles, Calif.

SEPT. 21-22—FARGO, N. DAK.
North Dakota Water and Sewage Works Conference. Annual Convention. Sec'y-Treas., M. D. Hollis, Bureau of Sanitary Engineering, Bismarck, N. Dak.

SEPT. 21-23—DENVER, COLO. (Cosmopolitan Hotel).
Rocky Mountain Section, A. W. W. A. Annual Meeting. Sec'y-Treas., B. V. Howe, 437 State Office Building, Denver, Colo.

SEPT. 22-25—NEW YORK, N. Y. (Hotel Pennsylvania).
New England Water Works Association. (Annual Convention). Secretary, Frank J. Gifford, Room 613, Statler Building, Boston, Mass.

SEPT. 23-24—HURON, S. DAK.
South Dakota Water and Sewage Conference. Sec'y, W .W. Towne, State Sanitation Board, Pierre, S. Dak.

SEPT. 28-OCT. 1—TORONTO, ONT. (Royal York Hotel).
Public Works Congress (American Society of Municipal Engineers and I. A. P. W. O. Executive Director, Frank W. Herring, 850 East 58th Street, Chicago, Ill.

SEPT. 29-30—COLUMBUS, OHIO.
Ohio Conference on Water Purification. Sec'y., T. R. Lathrop, Asst. Engr., State Department of Health, Columbus, O.

OCT. 1-2—COLUMBUS, OHIO.
Ohio Conference on Sewage Treatment. Annual Convention. Sec'y., B. M. McDill, Department of Health, Columbus, O.

OCT. 1-2—TORONTO, ONT. (Royal York).
Canadian Institute on Sewerage. Sec'y., A. E. Berry, Chief Engr., Provincial Dept. Health, Toronto, Ont.

OCT. 2-3—PITTSFIELD, MASS. (Hotel Wendell).
New England Sewage Works Association. Sec'y., F. W. Gilcreas, Div. Labs., N. Y. Dept. of Health, Albany, N. Y.

OCT. 6-7—WAUKESHA, WISC. (Hotel Avalon).
Wisconsin Section, A. W. W. A. Sec'y., L. A. Smith, Supt. Water Works, Madison, Wisc.

OCT. 9-10—GENEVA, N. Y. (Hotel Seneca).
New York State Sewage Works Association. (Fall Meeting.) Sec'y-Treas., A. S. Bedell, New York State Dept. Health, Albany, N. Y.

OCT. 12-15—FORT SMITH, ARK. (Hotel Goldman).
Southwest Section, A. W. W. A. (Annual Convention.) Secretary, Lewis A. Quigley, Supt. Water Works, Fort Worth, Texas.

OCT. 13-17—PITTSBURGH, PA.
American Soc. Civil Engineers. A. V. Karpov, Chairman of Local Committee, 801 Gulf Bldg., Pittsburgh, Pa.

OCT. 14-16—ATLANTIC CITY, N. J. (Hotel Haddon Hall).
Pennsylvania Water Works Association. (Annual Convention.) Secretary, F. Herbert Snow, 327 Telegraph Building, Harrisburg, Pa.

*OCT. 15-16—SARATOGA SPRINGS, N. Y. (New Worden Hotel).
New York Section, A. W. W. A. (Fall Meeting.) Sec'y., R. K. Blanchard, 50 West 50th Street, New York City.
*(Dates changed—originally Oct. 22-23).

OCT. 20-23—NEW ORLEANS, LA. (Hotel Roosevelt).
American Public Health Association. Exec. Sec'y, Dr. Reginald Atwater, 50 West 50th Street, New York, N. Y. Conference of State Sanitary Engineers. Held simultaneously.

OCT. 23-24—ATLANTIC CITY, N. J. (Hotel Ambassador).
New Jersey Water Works Associations. A Joint Meeting of the N. J. Section, A. W. W. A. (P. S. Wilson, Sec'y); N. J. Water Works Association (W. C. Flanders, Sec'y); South Jersey Association of Water Superintendents (Walter Spencer, Sec'y). Chairman of Committee on Arrangements, Prof. H. N. Lendall, Rutgers University, New Brunswick, N. J.

NEW FUNCTIONS FOR THE HYDRAULICS LABORATORY

By GEORGE E. BARNES*

Professor of Hydraulic and Sanitary Engineering, Cleveland, Ohio.

IMPORTANT hydraulic research is under way in several institutional laboratories today. Development work in the equipment field, and hydraulic design of new structures and projects have each given fresh impetus to the use of laboratories as proving grounds for newly conceived or more rational design.

Professor Barnes

The older policy of providing heavy or fixed equipment for routine testing and observation has yielded to a trend toward flexibility in the laboratory plan. The essentials for the laboratory include an adequate water supply, a constant level tank for insuring steady flow, flumes and tanks in which studies may be conducted, and measuring devices so that the flow may be precisely recorded. In addition, shop facilities are needed for maintenance work and for the fabrication of special instruments, models, and other devices required for a wide range of purposes. The laboratory should have free access and floor space for new work, and facilities for the handling of materials. A room is needed also for preparation of drawings, filing of records, and reference material. With various supplementary equipment and measuring devices, such a laboratory becomes a work shop in which hydraulic problems can be solved as they arise, and not merely a fixed display of hydraulic devices or machinery for demonstration purposes alone.

The technique of model studies in particular has been improved in recent years so that results are of increased value to the hydraulic designer. Nothing is so convincing or reassuring to the student as objective experiment which demonstrates that computed flow phenomena can be made to take place physically and actually measured for check, or that complex phenomena observed in the laboratory, can be sensibly predicted by analysis. Problems on such matters as variable flow, the hydraulic jump, and the discharge capacity of complex outlets, are seen in a new light when observed in action and in three dimensions.

The Warner Hydraulics Laboratory of the Department of Civil Engineering, Case School of Applied Science, in Cleveland, Ohio, is an example of the newer type of experimental laboratory, in which the student is in active contact with stimulating research. Industry and engineering organizations are encouraged to use the facilities on a cooperative basis.

In this laboratory a 50,000 gallon reservoir provides storage and equalization for continuous flows delivered by centrifugal pumps to a constant level tank. Outflow from the constant level tank is indicated and recorded by Venturi tubes, whose calibration is periodically checked by volumetric measurement of discharge. From the Venturi tubes and header system, flows may be directed at will through two main testing flumes or other equipment, to be returned to the reservoir for recirculation.

*Head, Dept. of Civil Engineering, Case School of Applied Science.

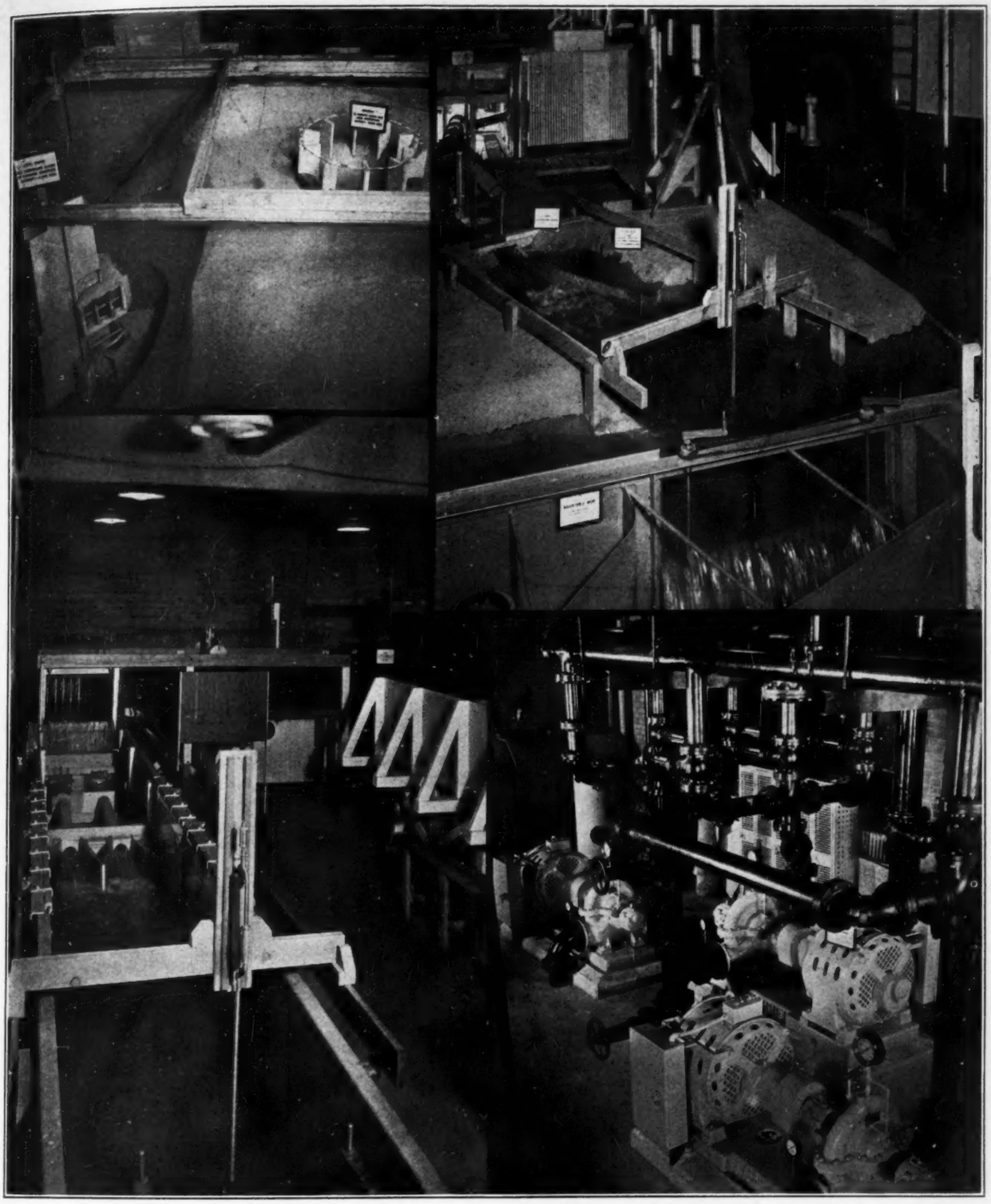
An intensive laboratory operating schedule was arranged recently to conduct a series of studies for the U. S. Engineer Department. Hydraulic model studies were made on eleven of the dams now under construction for the $34,000,000 Muskingum Watershed Project in Ohio. In order to secure experimental findings at the earliest possible moment for use by the designing staff, the Warner Laboratory was operated twenty-four hours daily for the better part of a ten months' period, using three shifts of assistants. The eleven model studies included capacity determinations for the gate-controlled outlet conduits, tunnels, and spillways. Performance tests were completed on preliminary and final designs for these hydraulic structures and for the stilling basins for each dam. In these basins the energy of high velocity discharge from the tunnel portals is dissipated by means of the hydraulic jump, as impounded flood waters are released into the channel below the dam.

The final designs which crystallized as the result of the model studies were less costly than those originally proposed and more effective. The model studies paid for their cost many times over in construction savings, and aside from this, gave invaluable assurance as to the probable behavior of these important flood control dams when put into operation. Personnel for the work on model studies was drawn both from the staff at Case School and from the U. S. Engineer Department.

Model Studies in Sewage Work Design

A model now in operation in the laboratory is a 1 to 6 scale replica of one unit of the Manhattan Grit Chambers of the Wards Island Project for the City of New York. In this project, a battery of four grit chamber units is interposed between the Manhattan intercepting sewers and the tunnel leading to the island. The four parallel units discharge through individual restricted or narrow effluent channels into a common downtake shaft leading to the tunnel. The hydraulic gradient in these units must be bracketed between the elevation in the downtake shaft which in turn depends on the level in the pump suction well on the island, and the level in the interceptors. Under conditions of storm flow, the grit chamber level is a function of the hydraulic gradient through the tunnel. Under conditions of dry weather flow, the sewage level in the downtake shaft is sufficiently low to permit the effluent channel to act as the control section for the grit chambers. Since flow in the effluent channel cannot occur at less than critical depth, proper depth and commensurate velocities are maintained in the grit chambers to insure proper settling of grit for all rates of flow. The hydraulic assumptions used in the design, were checked in the model, with flows reproduced to the two-fifths power of the scale ratio. The results show that no change in the design is warranted. But since the assumptions made in design included head loss factors rather arbitrary and without direct precedent, substantiating experimental results were considered well worth while.

Other experimental work in the laboratory includes a Venturi flume with capacity of about 3,000 gallons per minute, a 1 to 20 scale model of the outlet works of the



Warner Hydraulics Laboratory Models Used in Design on $34,-000,000 *Muskingum Watershed Project, Ohio. Top—Left: Gate Tower and Morning Glory Spillway, Pleasant Hill Dam. Bot-tom—Left: Outlet Channel, Stilling Basin, Twin Tunnels and Intake—Bolivar Dam. Top—Right: Stilling Basin and Outlet Tunnel—Pleasant Hill Dam. Bottom—Right: Circulating Pump Battery, Total Capacity* 3,000 *G.P.M.*

Germantown Dam of the Miami Conservancy District, and various hydraulic machinery.

Practical Aspects of the Laboratory

In the writer's experience, the design of hydraulic and sanitary engineering projects frequently includes problems which could be studied to advantage in the laboratory. The matter of head loss may be of great importance. For example, it is, of course, necessary to provide sufficient fall through the several units of a sewage treatment plant to allow for the sum of head losses in the individual units, each computed on the safe side. The list of units may include channels, transition sections, racks, fine screens, grit chambers, settling basins with weir overflows, aerated channels, measuring devices, and outfalls. For flow through the plant it is commonly

required that every gallon of sewage be pumped, and it follows that conservatism in allowing for the total fall where large volumes are handled is certainly reflected in the pumping charges. These, if capitalized, would indicate the penalty paid for too liberal head loss allowances. The value of any supplementary method by which such allowances might be rationally reduced is apparent to all.

Importance of Solids Distribution

Computations unsupported by experiment may result in other weak spots in the design. The assumed effectiveness of settling basins whose capacity is rated on full displacement may be substantially in error. Where batteries of tanks are fed by common headers with lateral take-offs, there may be inequality of loading, both as to the volume handled and as to the percentage of settleable solids carried to various units.

The newly built Joint Meeting Plant at Elizabeth, N. J., designed by Alexander Potter of New York City, picks up the flow from a main sewer through an easy-curved, double-barreled transition section from which the flow is deflected by a swinging gate to a pair of coarse bar racks. The discharge from each rack is split symmetrically two ways to grit chambers. Each pair of grit chambers discharges again into an effluent conduit, at the end of which the flow is divided equally to flow to the centerline of the settling basins in which very complete dispersion is assured by perforated baffles at the inlet. Necessarily such a layout is conducive to best possible distribution of flow, and also to the equalization of solids deposition in the several units.

However, there is not usually space available for such an ideal layout and the designer is frequently forced to compact the plan so that a single channel will feed more than two take-offs at a single point. Thus at one plant, a battery of Imhoff Tanks is fed by a common header channel which is reduced in section as each successive unit is passed. Measurements show that the percentage of solids entering varies greatly for the several tanks, however equalized the volume of flow may be, so that the first tank is practically devoid of sludge, and the other units are to the same extent overloaded.

At another plant, the compacting of the influent channel approach to grit chambers and screens likewise is at the expense of hydraulic symmetry, and here also there is overloading of certain units, and incomplete usage of others.

At still another plant, there is a take-off by gates to four grit chambers and one by-pass channel in the original layout, to which has been added another take-off leading through a short inverted siphon to the influent header of a detritor. The solids distribution in the several units is nowise equal. The contemplated displacement capacity of the detritor is not at all uniform. Measured velocity contours in this unit show dead areas and areas of accelerated velocity above the optimum which it may be possible to govern by further adjustment of the deflectors.

The Question of Sludge Bulking

Bulking of activated sludge tanks should be remedied ahead of the final tanks, of course, but short-circuiting in the latter is not free of blame in these undesirable sludge losing occurrences.

Short circuiting in aeration tanks is not likely to occur where the length of run is great, or when tanks are used in series, but in one activated sludge plant the insertion of baffles in short tanks remedied bulking by increasing the aeration period substantially so that with the same air consumption per gallon, the dissolved oxygen in the mixed liquor jumped from 0.5 p.p.m. to 2.0 p.p.m.

Dependability of Model Tests

Engineers are sometimes skeptical of the dependability of small scale experiments. It is freely admitted that small scale experiments may be totally inappropriate for certain types of problems. However, in some of these cases laboratory methods may be used in the field to advantage in connection with full scale plants. The sewage detritor experiments mentioned above were taken in the field with a home-made Pitot tube, the surveying being made by wading measurements.

It would be a great service, also, if head losses in full scale plant operation were carefully checked against the original design assumptions. It is difficult, however, to find someone to foot the bill or to spend the time to secure such measurements, as useful as these may be. Finally, to be of greatest service laboratory work must be on pertinent problems and prove useful to the designer or operator.

At Case School of Applied Science the laboratory staff and also the students have had opportunity to pursue research both on the campus and at municipal plants. The Warner Hydraulics Laboratory is operated under the direction of the writer, assisted by G. Brooks Earnest, Assistant Professor of Civil Engineering, and W. J. Hotkie, graduate assistant in the Department of Civil Engineering, Case School of Applied Science, Cleveland, Ohio.

▼

Harry Hall Made Chief of Washington Sanitary District

Harry R. Hall

News has been received that Harry R. Hall has been permanently appointed Chief Engineer of the Washington Suburban Sanitary District — with headquarters at Hyattsville, Md. Mr. Hall was for many years Deputy Chief Engineer under Robert B. Morse, who met an untimely death early this year.

Mr. Hall, a native son of Boston, Mass., and a graduate of Massachusetts Institute of Technology (1907) joined Mr. Morse in 1912 as Assistant Chief Engineer of the Maryland Department of Health. With his "Chief" he went to the newly created Sanitary District, embracing Suburban Washington, as Deputy Chief in 1918, and has deservedly won the elevation which the new appointment brings to him. Always progressive, he has served as Chairman of the 4 States Section of A.W.W.A.; and as President of the Maryland-Delaware Water and Sewage Works Association; is now a Board Member of the Federation of Sewage Works Associations and prominent in the work of Maryland's State Planning Commission; a member of numerous leading technical societies and associations.

Congratulations and best wishes to our good friend—and Robert Morse's good friend—Harry R. Hall—who he would have wished to see "carry on" as the new "Chief."

THE WATER WORKS AND THE COMMUNITY*

By N. R. RITCHIE
Supt., Everett Water Company
Everett, Penna.

THE MERITS of a public enterprise are usually measured in terms of service value received. When we have at the head of our government an organization that is devoting its service to the needs of its people, we invariably say that we have a successful form of government.

The public utility can well be considered a public enterprise, whether it be publicly or privately owned; for it is the specific purpose of a utility to serve the public, just as earnestly as the government serves its people. The water works, especially, provides a service that is unparalleled by any public enterprise in the field. Not only does the water works supply a commodity that is indispensable in the life of every individual, but it serves to its public a water that is pure, palatable and safe—and without a tolerance of interruption.

"Water, Water Everywhere!"

During the recent flood catastrophe, which covered the great industrial districts of our country, the importance of a stable and dependable water supply became the more in evidence. Almost without exception, power, light and communication facilities were temporarily halted. And, it is quite true that without these excellent modern services, we were greatly inconvenienced; but we did not suffer a hazard in their absence. In some few cases, the water supplies of towns and cities were exhausted before the water works could be recommissioned. Here indeed there could be no substitute and drinking water either had to be transported or the citizens were forced to evacuate their homes. The words of the ancient poem, "Water, water everywhere, and not a drop to drink," were truly applicable in these unfortunate cases and useful water the more appreciated.

Happily for all those people in distress, the great majority of public water systems were able to render uninterrupted and safe service in the face of the crisis. This excellent service, rendered at a time when disorganization reigned, can be attributed, for the most part, to the untiring efforts of conscientious and loyal water works operators. These men and women will of course be unsung heroes, but in the minds of many people, they will be appreciated for their true value.

"Water—The Commonplace"

Not only is it incumbent upon us to have a stable water supply in times of major disaster, but it is of utmost importance that we have the indispensable commodity—water—in our homes every day of our lives. When we go to a water spigot and draw out a quantity of water, we seldom pause to realize that here we are receiving a real service. We are receiving a clear, sparkling water that is free from tastes and odors, and above all a pure product that we can use without hazard to our health or well-being.

Until recently, typhoid fever was a very fatal disease. A number of years ago, the typhoid death rate was one hundred deaths to every one hundred thousand population. That was during the time that public water systems were in their infancy. Today, when nearly all communities are served by public water systems, typhoid fever is a rapidly disappearing disease. Few stop to question now the safety of a public water supply.

We are equally indebted to the public water systems for the protection of our property as well as our health, for at any time a terrible fire may break out and without an abundant supply of water under pressure, little could be done to combat the flames. Several years ago, a fire broke out in a small town in Southern Pennsylvania. The flames fanned by a high wind soon spread over the entire business section and in a short time the whole of the village was a blazing inferno. In a few hours, the town had been reduced to ruins and many thousands of dollars worth of property had been destroyed. No public water supply, no water available, and an entire town swept away. Aside from the fact that available fire hydrants are always a great benefit to fire fighting, their very presence in a community saves property owners many dollars each year in reduced insurance premiums.

Just as important as these services are to the public, the public water system serves many useful purposes in the home. How convenient and useful is the modern bathroom of today. It not only produces comfort and luxury, but it also provides sanitation and protection to our health. Summer drought no longer destroys our gardens and lawns, for always water is available for sprinkling. With very little labor on our part, we can keep our automobile clean and shining by frequent washings with the hose. And, now, comes modern air conditioning—the comfort afforded by water cooling from the public supply. It seems that the water supply performs so many duties for us in the home that we could scarcely do without it for even one day.

"Cheaper Than Dirt"

For the services such as we receive from the public water works, one would think that the cost would be almost prohibitive. Yet in reality our water service is the cheapest thing that we can buy. Very often we hear quoted the old adage, "As cheap as dirt"; however, when we investigate the price of our water service, we find that it is really, "Cheaper than dirt." In most municipalities a thousand gallons of water costs about thirty cents. Sold by weight, for this quarter and a nickel we get almost four tons of water. We would not expect our local truckman to deliver onto our lawns or gardens four tons of dirt for less than ten times that price. Notwithstanding the fact that water is delivered so cheaply to consumer, many water works have paid large amounts of money into city treasuries from their earnings, thus effecting large decreases in taxation. Many times water works have also made large contributions to municipal projects of free water for one purpose and another.

The public water works may also be considered an essential factor in the business of any community because it provides steady employment for a number of workers. Throughout the depression years, water works' employees were given steady work, mostly at regular wages. The water works usually buys its supplies locally; and, in this manner, aids the local merchant.

Because water works' operators seldom headline their activities, the public usually fails to realize the essential significance of a public water supply; however, it is my opinion that some day the true light of this vital service will reach the front page, and then the faithful water works operator will receive his just reward for having honestly and earnestly performed his duty in the cause of public service. At least, let us hope so!

Water Works and Sewerage—September, 1936

*This paper, presented before the Pennsylvania Water Works Operators Ass'n at State College, Penna., won for its author the President's Cup.

EDITORIAL

The Voice of Two Presidents
And the Plight of the $4.00 Superintendent

IN this issue is heard the voice of the presidents of of America's two leading water works associations. The theme in the statements of each is the value of membership in one or both of the two associations which have been responsible for advancement of technical and economic phases of water supply practice and increased knowledge of water works operators; hence, their genuine and tangible value to water utilities.

In addressing the Central States Section of the American Water Works Association, during its recent annual meeting in Cleveland, Ohio, President W. W. Hurlbut struck a key note which should be echoed and re-echoed throughout the water works world. We refer to his stressing of the undebatable fact that from every water works, large and small, privately or municipally owned, should be expected the support of the national water works association in a tangible manner. This, because of the many benefits already derived in the nature of advancement of water supply practices, and, more especially in order that benefits to water works in general might be even greater in the future. To this end, the most definite way open to corporate and municipally owned works is that of maintaining a Corporate Membership in the association. It is this minimum extent of warranted support that President Hurlbut believes should be forthcoming. That the investment, represented in the cost of Corporate Membership, will yield worth while returns to the municipal or privately owned water utility is hardly debatable. With this "value-return" argument plus the argument against a "take all—give nothing" practice (to reach the selfish, as well as the conscientious type, of municipal officials), it is possible for active members and friends of the association to do much in the way of strengthening it by "selling" the Corporate Membership idea. If not by direct selling, then indirect selling by suggesting and outlining the idea to City Managers, Mayors, Water Commissioners, and others in authority. If every reader of this page would undertake to put before the local authorities the expressed thoughts of the President of A.W.W.A. much will be accomplished. And, who can be so much a fatalist as to assume that a Corporate Membership will not be the net result of his efforts—tomorrow, if not today.

It was resolved, by vote of those present at the business meeting of the Central States Section, that members of the section were whole-heartedly in favor of advancing the plea of President Hurlbut for the supporting Corporate Membership expansion and would participate in efforts to that end. Here is an opportunity for members of the Central States Section to prove that actions speak louder than words. And, if every section of A.W.W.A. should take like action and prosecute the avowed intentions, as if their vote constituted an individual promise, the president and directors of A.W.W.A. need have no fears concerning forthcoming support in the future from those most benefited—America's municipally and privately owned water utilities.

Selling is an interesting and absorbing occupation. Selling carries with it a very tangible proof of accomplishment. In one way or another we all must at one time or another become salesmen in the broad sense of the word. To be successful is, first, to be effectively sold on that which the salesman is trying to sell. And, if he who here reads needs any further selling to convince him of the value of the water works association to the member, let him turn to the analysis and arguments presented on another page of this issue by Roger W. Esty, Superintendent of Water at Danvers, Mass., and President of the New England Water Works Association. President Esty points to the lamentable (somewhat astounding fact to many) that by actual statistics, recently gathered, the average pay of water works superintendents (those men who are the responsible heads of the No. 1 public utility, but so inadequately appreciated) amounts to but $4.00 per day. Just think of it! This situation is a challenge to the two leading water works associations, that something be done about it in an effort to improve the position, the financial status and the future security of water works operators. When one reviews statistics of the Federal Works Progress Administration, appearing elsewhere in this same issue, and finds that the average wage paid relief-workers (irresponsible for the most part) on water and sewage projects was 43 cents per hour, and compares this with the hourly wage paid by municipalities to the average responsibility-shouldered water works superintendent, no further argument is needed to show what water works associations should be attempting to do in behalf of their operating members and prospective members.

In arriving at the average pay of water works superintendents, it would have been enlightening and interesting if the statistician had sub-divided the group into members and non-members of water works associations. We would hazard the prediction that the two figures arrived at would show a marked difference in favor of association members. Further, an additional breakdown would show, we believe, a greater advantage in favor of those operators whose names are most frequently found on the registration lists of meetings. One might argue that this only shows that operators who regularly attend meetings, for what President Roger Esty from experience so effectively states they are worth, are progressive in matters at home as well as in their appreciation of the value of attending meetings. We hardly believe, however, that the many successful operators, who have become consistent attendants at meetings, would fail to attest the fact that progress at home and participation in meetings go hand in hand. Further, that inspiration and initiative are wrapped up in the same package taken home from meetings attended. If the experiences of this writer have any significance in testifying to this particular value of meetings, it can be said that the needed "spring-tonic" was consistently supplied by A.W.W.A.'s "clinics."

There are those who question "How can a $4.00 a day superintendent afford to be a member of water works associations?". *We* ask another—"How can he afford *not* to be a member?". In either case the solution to his problem is found in the timely proposal of President Hurlbut. Get the Municipal Water Department to take out Corporate Membership and in consequence underpaid superintendents will receive most of the privileges and benefits of an Active Membership. Then, if they attend the meetings, which is rightly an operating expense item warranted in every water works budget, they receive *all* of the benefits and, what's more, so does the water department and the tax-payers. We can all do a worthy job in pushing the idea and "selling" Corporate Memberships.

L. H. ENSLOW,

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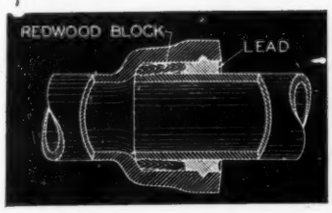

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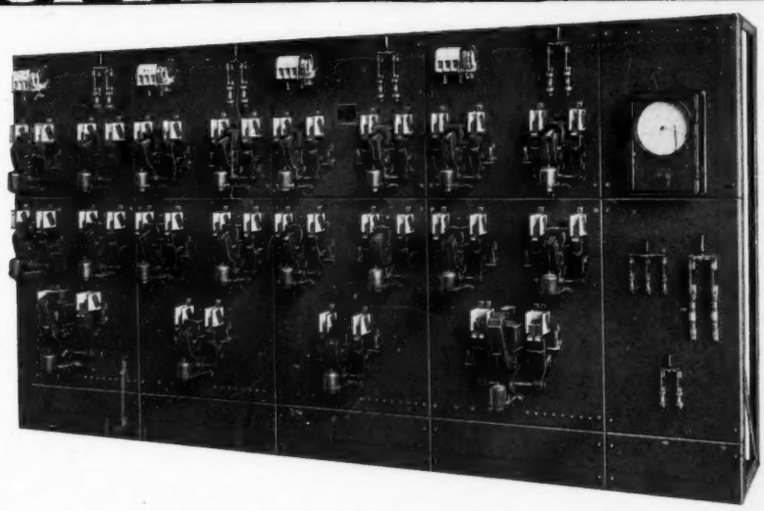

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EQUIPMENT NEWS

"Surfaseal" (a Rubber Paint)

In the way of protective coatings, there is nothing more resistant or tougher than pure rubber.

From Collord, Inc., of Detroit, Mich., makers of rubber linings for tanks, comes an announcement of their new rubber-paint, "Surfaseal." The product has been made decorative (available in colors), as well as easy to apply to a variety of surfaces.

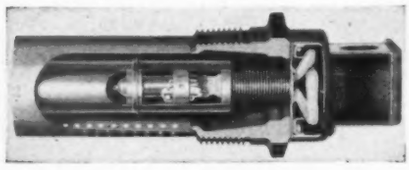
"Surfaseal" Brushing Rubber is a true rubber paint which adheres well to sand-blasted metal, concrete or other cleaned surfaces — resisting acids, alkalies and fumes. Drying to a hard *glossy* finish, it is available as "Surfaseal" No. 1 for general use where severe corrosion is the problem; as "Surfaseal" No. 2 (harder finish) for outside use on concrete, brick or metal surfaces to prevent attack by moisture or fumes. Both are guaranteed to stop corrosion.

For more detail, address Collord, Inc. (Dept. W. S.), 1430 Rosedale Court, Detroit, Mich.

▼

A Novel Float Switch

A simple float-operated switch for indicating or controlling liquid levels has recently been developed by McDonnell & Miller, of Chicago. The working mechanism (see cut-away view) consists of a mercury switch inside of a seamless float which is attached to the head by means of a flexible metallic bellows. The float moves within a protective chamber.



Low Water Cut-Off

When the liquid level reaches a height that will move the float the mercury switch makes contact to sound an alarm, light a warning light, or start up a motor operated pump or other electrical device. It may also be installed submerged, at a predetermined low level, to cut in a motor-pump unit or sound an alarm, as required. In suction wells it is useful for safeguarding pumping units by cutting out such units before the pump takes air. The McDonnell Low Water cut-off unit is widely used by boiler manufacturers as a dependable cut-off switch when the boiler water level falls to the danger point.

The "M. & M." Float Switch is being built in several models. One design is equipped with a 3-wire switch so that it makes one circuit and breaks another when the mercury contact is made. Thus it will cut out or start pumps, and at the same time sound an alarm or light a warning signal.

In water-works and sewerage operations there are multiple applications for such a simple float-switch. Having "the stuff" to stand up inside of boilers, is sufficient proof of its dependability.

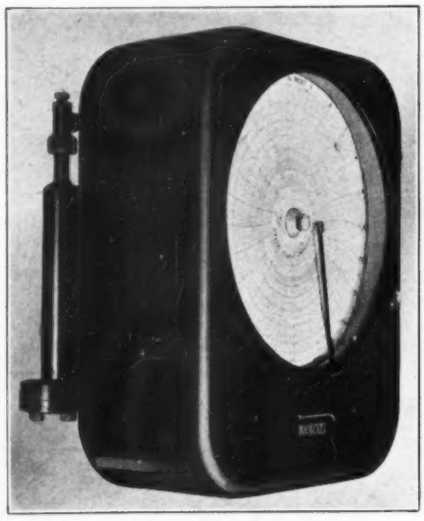
For descriptive literature address McDonnell & Miller (Dept. "W."), Wrigley Bldg., Chicago, Ill.

▼

Cochrane Orifice Meters

The Cochrane Corporation, well known Philadelphia firm and for many years identified with the industrial power fields, announce the new Cochrane Orifice Meter for water, gas, air and steam.

The indicating and recording equipment is used in conjunction with flow through orifices, flow-nozzles or Venturi tubes. The features enumerated by the manufacturer include: Direct reading integrator; 12 inch



Cochrane Orifice Meter

diameter charts; spring or electric clock for driving charts and integrator; interchangeable manometer tubes to permit altering meter capacity; safeguards in both high and low pressure chambers, to prevent loss of mercury; large float with high buoyancy; throttling bushing to dampen violent fluctuations in flow; pressure tight bearings; ranges of meter from one inch of water to two hundred inches.

The new meter, introduced to meet demands for an accurate but inexpensive instrument, is effectively illustrated and described as to its working parts, etc., in a new bulletin (No. 2092)—"Cochrane Orifice Meters." Address, Cochrane Corporation, 17th and Alleghany, Philadelphia, Pa.

▼

Jointless Concrete Pipe Construction

A method of constructing jointless concrete pipe and culverts without the use of expensive interior forms has recently been developed by the Jointless Concrete Pipe Company, Los Angeles, Calif.

This method, known as the Inner Liner System, was developed to permit the use of a monolithic outer shell, cast in place over sections of *precast* concrete inner liners. The method is recommended particularly for use on pipe, culverts, storm drains, etc. (diameters from 12 in. to 5 ft.), because of the impracticability and high cost of using removable interior forms.

Precast in thin reinforced sections over steel forms adjacent to the trench, the inner liners are set in place to act as inside forms during construction. They remain in place, becoming an integral part of the completed structures, furnishing a smooth, low friction, inside surface. With the inner liner in place, the outside shell is cast monolithically, thus providing a jointless outer shell.

For fuller details, address the Jointless Concrete Pipe Co., 315 W. 5th St., Los Angeles, Calif.

▼

"E.B.G." in New Quarters

Electroc Bleaching Gas Company, pioneer producers of liquid chlorine in America, have moved their executive and sales offices to the Lincoln Building at 60 East 42nd Street, New York City. On the 30th floor of this modern skyscraper located in the "chemical center" of New York (opposite Grand Central Terminal and across the street from the Chemists' Club) the new offices of "E.B.G." and its magazine, *The Pioneer*, are spacious, attractive, conveniently located. To friends and customers "E.B.G." and *The Pioneer* extend a cordial invitation to visit their new home—the Lincoln Building, New York City, is sufficient address to remember.

▼

Columbia Alkali Enters Liquid Chlorine Field

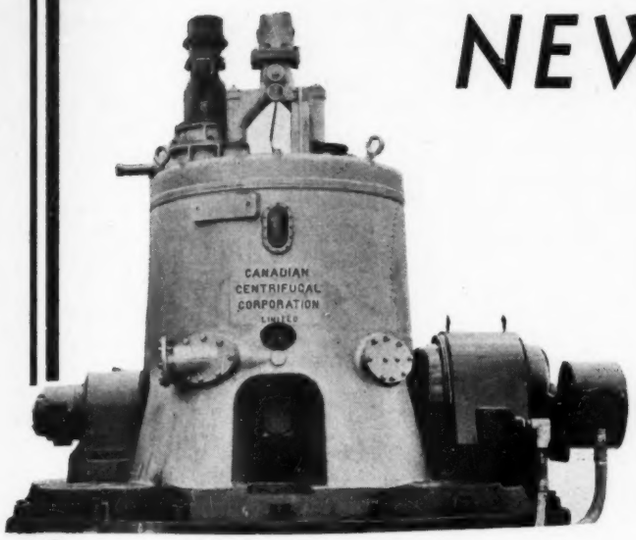
Columbia Alkali Corporation, well-known subsidiary of Pittsburgh Plate Glass Company, have recently announced that liquid chlorine and electrolytic caustic soda constitute new products of this concern.

From the new plant at Barberton, Ohio, equipped with the most modern and efficient chlorine cells, shipments are already being made in single and multiple unit tank cars and in 100 and 150 lb. cylinders. The tank cars, ton containers, cylinders and valves are of the latest improved design—"Standard Chlorine Institute Valves" being employed for safety and trouble-free service.

For nearly half a century Columbia Alkali Corporation has occupied an important position in the production of soda ash, caustic soda and by-products. And it is a logical and natural development that electrolytic caustic soda and liquid chlorine should be added to the line. The modernly designed and equipped executive offices of Columbia Alkali Corporation are located in Radio City on the 43rd floor at 30 Rockefeller Plaza, New York. Branch offices are maintained at Chicago, Pittsburgh, Cincinnati and at the plant in Barberton, Ohio.

To better serve its customers Columbia Alkali has added to its staff Mr. Chris F. Bingham, former Superintendent of Filtration at Richmond, Va., who becomes Columbia's Engineer of Technical Service. Mr. Bingham's training as a Chemical Engineer and his operating experiences in the sanitary field fit him well for the position created.

CENTRIFUGALS
NEW PROCESS



•THIS machine specifically developed for the sanitary field. Will dewater raw or digested sludge. Produce a low moisture cake. Incineration without additional fuel. No conditioning chemicals required.

◈ ◈ ◈

Machines now operating in sewage plants of Collingswood, New Jersey and Toronto, Canada, where test runs and demonstrations are now being made.

◈ ◈ ◈

Two machines will be installed at the new Niagara Falls Sewage Plant for dewatering screenings and sludge. George L. Watson, Cons. Engr., N. Y. C. Canuso & Son, Philadelphia, Pa., Contractors.

◈ ◈ ◈

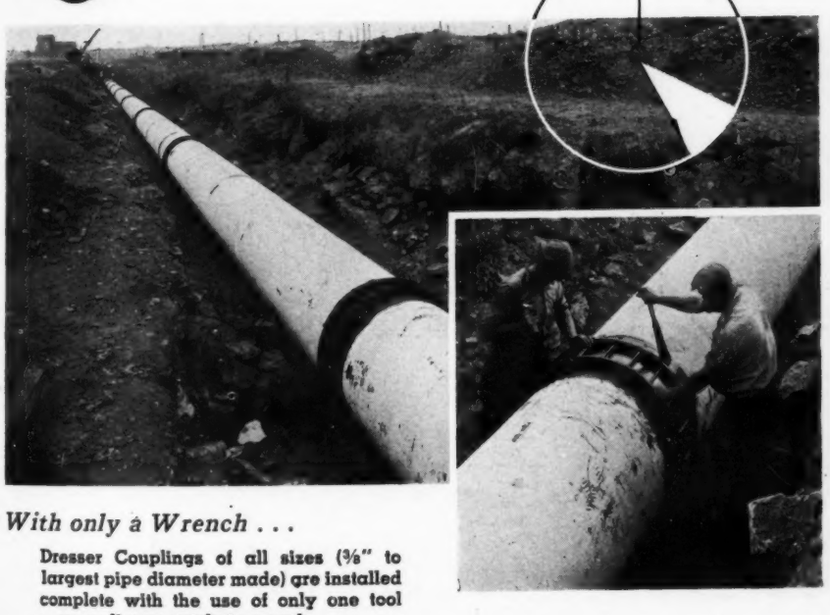
Additional information upon request

AMERICAN CENTRIFUGAL CORPORATION

115 BROADWAY • NEW YORK CITY

"Greenhorns" at Pipe-Line Work

...YET THEY COUPLED THE FIRST THREE SECTIONS IN A SINGLE HOUR!



Unskilled. On relief. No previous experience to guide them. Just a game of "pick-up" labor, brought to the job at 4 o'clock one afternoon. Too late to start work (they thought!) but—*in that single hour before quitting time*—they easily coupled three bottle-tight sections of pipe on this 36" pressure-equalizing line in Buffalo.

Have YOU tried this speedy, cost-cutting system of joint construction that so many cities are using with such remarkable results? Folder No. 355 tells you how to get *true* economy with Dresser simplicity, flexibility, strength, and permanent tightness. Ask for this folder by number.

With only a Wrench . . .

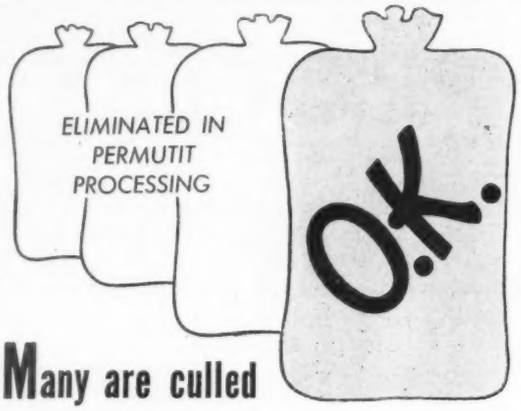
Dresser Couplings of all sizes (3/8" to largest pipe diameter made) are installed complete with the use of only one tool —an ordinary ratchet wrench.

DRESSER COUPLINGS

S. R. DRESSER MANUFACTURING CO.
BRADFORD, PA.

In Canada:
Dresser Mfg. Company, Ltd., 60 Front St., W., Toronto, Ont.

ZEO-DUR
PERMUTIT GREENSAND ZEOLITE



Many are culled
BUT FEW ARE CHOSEN

If you think Permutit Zeo-Dur is just greensand, you should see it processed. Although the greensand is literally hand-picked from the deposit, from two to three bags of this material are eliminated to produce one bag of Permutit Zeo-Dur.

First: Greensand is hand-picked from the raw glauconite deposit. **Second:** Washed in trommels; coarse rejects removed. **Third:** Washed in classifiers to eliminate clay and fines. **Fourth:** Boiled with caustic soda to remove residual clay. **Fifth:** Rinsed to remove caustic soda. **Sixth:** Special stabilizing baths make the granules tough, hard, and long-lived. **Seventh:** Again passed through classifiers for sizing and to remove stabilizing solutions. **Eighth:** Dried under close temperature control. **Ninth:** Dust removed in air separator. **Tenth:** Final screening. **Eleventh:** Weighed. **Twelfth:** Bagged.

In this long process from 60% to 75% of the original material is eliminated. Only refined greensand Zeolite remains—pure, active, long-lasting. For complete details of this interesting process, ask for the Permutit booklet: "Zeolites — Mining, Processing, Manufacture and Uses." Address The Permutit Company, Dept. G1, 330 West 42nd Street, New York, N. Y.

Permutit
Water Conditioning

CATALOGS AND LITERATURE RECEIVED:

[*Any of the publications received in this section can be secured from or through Water Works and Sewerage, if such be desirable.*]

"Screw Type Pumps"—For lifting relatively large volumes of water or sewage against moderate heads, engineers will find the screw type pump worthy of consideration. Morris Screw Pumps are illustrated in a new bulletin, describing the features and performance of this interesting and useful type of semi-centrifugal pump which has for some time been successfully used abroad.* In sizes from 20 to 40 inch, with efficiencies in excess of 90 per cent, the especial features of Morris Screw Pumps and application for drainage, irrigation and sewage pumping, water recirculation, etc., are set forth, accompanied by illustrations. (*By coincidence, on another page in this issue is to be found an article, descriptive of Screw Type Pumps and their successful adaptation abroad.—Ed.) For Bulletin 162—"Morris Screw Pumps"—address Morris Machine Works, Baldwinsville, N. Y.

"Link-Belt Tritor Screens"—From Link-Belt Company, well-known manufacturers of sewage treatment equipment, has been received an illustrated bulletin, descriptive of the "Link-Belt Tritor Screen"—an interesting combination of bar-screen and grit chamber (grit pocket). The unit is mechanically and automatically operated. Especially for small and medium-sized plants has this combination unit been developed to eliminate the expense of providing two separate units. The same bulletin pictures and describes features of Link-Belt's well-known Straight-Line Bar Screens. Ask for Folder No. 1587. Address Link-Belt Co., Philadelphia, Pa., or Chicago, Ill.

"Precision Laboratory Equipment":—A new 20-page bulletin from Precision Scientific Company, manufacturers of laboratory equipment, illustrates and describes their complete line of Kjeldahl equipment for digestions and distillations. For a copy of Bulletin 151 address Precision Scientific Company, 1736-54 North Springfield Ave., Chicago, Ill.

"Automatic Sump Pumps"—Victor Equipment Company of San Francisco, Calif., have issued a bulletin, descriptive of Victor's Kimball-Krogh automatic sump pumps, designed for draining cellars, pump rooms, pipe galleries, and the like. These drainage pump units, as illustrated and described, come in two types—one for permanent mounting, the other a semi-portable unit. With self-lubricating OILITE sleeve bearings, these units are designed to operate with little or no attention. Dimensions and capacities are tabulated. Ask for Bulletin No. 625—address, Victor Equipment Company (Kimball-Krogh Div.), 515 Harrison St., San Francisco, Calif.

"Shielded Arc Welding"—Lincoln Electric Company, believed to be "the World's largest manufacturers of arc welding equipment," have a new bulletin which relates the advantages and economies resultant from pipe jointing by electric-arc welding, because of the simplicity and low cost. Comparative jointing cost data are pre-

sented and methods, most useful, are illustrated, as are typical examples of the adaptability of shielded arc welding in new and revamped piping systems. A variety of arc-welding equipment, useful also for thawing frozen water pipes, is illustrated on the back cover. For a copy of "Lower Piping Costs With Shielded Arc Welding," address Lincoln Electric Co., Cleveland, Ohio.

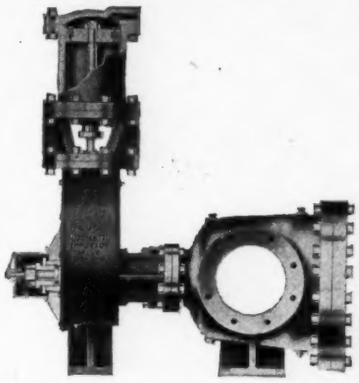
"Boiler Water-Level Control"—Northern Equipment Company of Erie, Pa., specialists in boiler operation control, has distributed an interesting and brief story of the "Control of Boiler Water Level with Rapidly Flocculating Loads," which recites experiences of an important company using their Copes Double Control Regulators. The installation and its functions are illustrated, as well as the results. The latter are told in picturized style by actual reproductions of charts taken from plant operating records. If your problem involves boiler operations, look into this. Request Form No. 401—from Northern Equipment Company, Erie, Pa.

"Ford Supplement":—Ford Meter Box Company have issued a Supplement to Catalog No. 35, which illustrates, describes and quotes prices on the popular and reasonably priced "Ford Portable Testing Tank for Water Meters"; "Type X Covers for Meter Settings"; "The 80 Series Copper-Setter," for meter settings on riser pipes; "The Valve Copperhorn" for basement meter settings; "Ground Key Valves" for services; and "Pack Joints for Copper-Setters." For this new Ford Supplement to Catalog 35 address Ford Meter Box Company, Wabash, Ind.

"Standard Instruments"—Is the title of the fresh and crisp Julien P. Friez & Son's condensed edition of their complete catalog of instruments used in measuring and recording temperatures, humidity, barometric conditions, wind-velocities and direction, sun-shine intensity and duration, rain-fall, and water-levels for flow measurements and records. The listing and picturization of the modernized line of Friez "Standard Instruments," put out by this well-known, 60-year-old firm, constitutes a ready reference catalog, which sets forth, in clear style, just what the individual instruments are used for, presents a brief description of each (supported by the picture), and states the prices. This space and time-conserving catalog "digest" should prove serviceable and desirable to many engineers and operators. For a copy of "Friez Standard Instruments," address Julien P. Friez & Sons, Baltimore, Md.

"Cochrane Meters"—Is a new bulletin describing and illustrating Cochrane Electric Flow Meters for measuring water, gas, air, sewage, steam, and other fluids. Distinctive is the utilization of the highly accurate and sensitive galvanometer null principle for translating differentials, created by Cochrane's Self-Contained Orifice Metering Element. Through the nearby Cochrane Transmitter head differential is converted into electric current flow over wires to one or more Cochrane Indicating, Integrating and Recording Receivers, which may be located at desirable remote points, in addition to the central station. An effectively illustrated description of the essential units and explanation of their operation, together with a discussion of outstanding features of Cochrane Electric Flow Meters and Receiving Instruments, completes this enlightening and interesting Cochrane Publication No. 2096. For a copy, address Cochrane Corporation, Philadelphia, Pa.

Smooth, Dependable Control

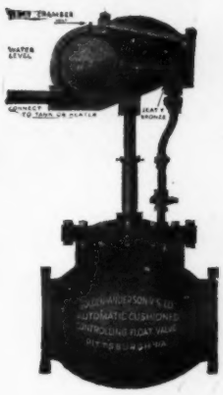


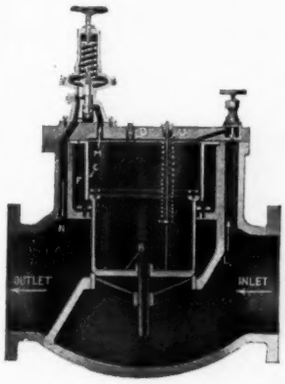
THRU-FLOW CONE VALVE

Afford full pipe line flow without friction loss. Always oil lubricated. Axially unseats before it rotates without friction, rub or wear. Especially desirable for sewage disposal service.

CONTROLLING FLOAT VALVE

Ideal for heaters, vats, tanks, etc. Valve entirely self-contained and operates without water spill. Sensitive in operation and indestructible due to air and water cushioning and heavy bronze mountings. Sizes to 24".



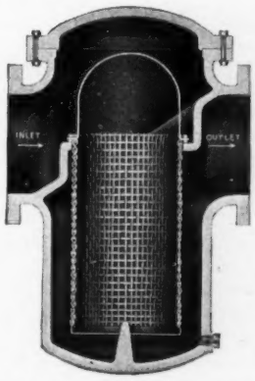


WATER REDUCING VALVE

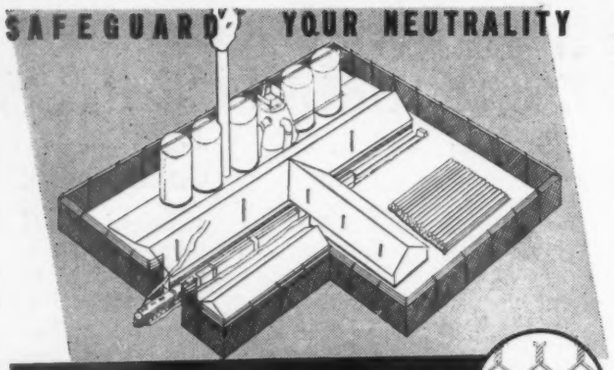
Assures positive control of low pressure. Air and water cushioning prevents shock or hammer. Supplied with single or dual pilot controls for any service. Sizes to 24".

WATER STRAINER

Large capacity with minimum friction loss. Strainer basket quickly accessible and easily cleaned. Basket mesh furnished to suit any service conditions. Sizes to 24".



GOLDEN-ANDERSON VALVE SPEC. CO.
1350 FULTON BLDG.
PITTSBURGH PENNA.



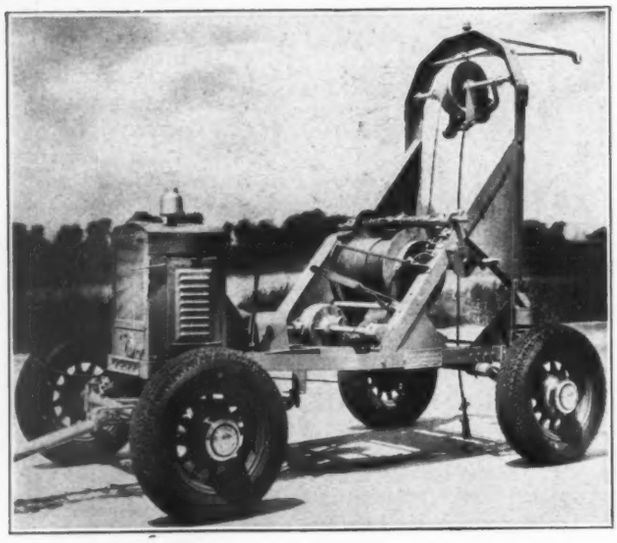
In case of trouble in the neighborhood, a sturdy enclosure of Pittsburgh Chain-Link Fence around your plant is your best insurance against damage. Pittsburgh Fence is made to withstand the hard knocks of everyday accidents. Send us your blue prints for an estimate of cost of fencing your property. No obligation.

Pittsburgh Fence

PITTSBURGH STEEL CO.

754 UNION TRUST BLDG. PITTSBURGH • PENNA.

SEWER CLEANERS



O.K. Champion Sewer Cleaners have passed their 25th year of satisfactory performance. We now make three sizes—Junior—Standard and Power Cleaners. Hundreds of O K Champion Cleaners are in use in 42 States and Canada.

The Power Cleaner illustrated above is working to the entire satisfaction of the purchasers in Atlantic City, N. J., Little Rock, Ark., and others.

We solicit your inquiries for literature and prices. Deliveries can be made promptly.

CHAMPION CORPORATION

4714 Sheffield Ave. - - Hammond, Indiana

"Blue Streak Sludge Gas Engines"—A bulletin, devoted to a new gas engine to the sewage works field, from an established firm, Climax Engineering Company of Chicago, describes the recent installation of Climax Blue Streak engines operating on digester gas at the Aurora, Ill., sewage treatment works. The two six-cylinder units pictured are direct connected to two American Well Works centrifugal pumps lifting 6.6 M.G.D. of sewage. Unique is the automatic variable speed control of the engines and pumps through float control mechanisms in the suction well, to pump at rates from 3.5 to 12 M.G.D. For this illustrated "Blue Streak" bulletin, address Climax Engineering Company, 111 W. Monroe Street, Chicago, Ill.

"Stelco Bituminous Coatings"—Is the title of a combination bulletin-catalog from the Stelwagon Manufacturing Company of Philadelphia, one of America's longest established producers (1853) of protective bituminous coatings and enamels for corrodible metals. The three major products described are Stelco Pipe Line Primer, Stelco Pipe Line Enamel and Stelco Pipe Dip Enamel. Characteristics of each, methods of application, and covering capacities, are set forth—all of which are guaranteed not to impart tastes to the water. Being acid-proof, Stelco coal-tar-base coatings are also recommended for use around water and sewage treatment plants. In the rear of the brochure are listed the titles of numerous technical "Service Bulletins" put out by the company to cover special applications, such as "Manual Coating Instructions," "Coating and Lining Cast Iron Pipes," "Protecting Stand-pipes and Elevated Tanks," etc. Condensed product specifications completes the brochure. For a copy of "Stelco Bituminous Protectives," or any of the "Technical Service Bulletins" listed, address Stelwagon Manufacturing Company, 19th St. and Washington Ave., Philadelphia, Pa.

"Dieform Copper Fittings"—Bailey Meter Company, in a recent leaflet, describes and illustrates the features of their patented "Dieform Compression Fittings," ideal for copper tubing lines or house services, in sizes of 2 inches down. With a slight flare, easily given the end of the soft copper tubing, the Dieform Fitting makes an absolutely tight compression joint without restriction of the flow-through area. Numerous applications are listed. For the "Six Reasons for Dieform Fittings," address Bailey Meter Company, 1050 Ivanhoe Road, Cleveland, Ohio.

"Universal Gear Drives":—Is an illustrated brochure containing "Engineering Data on Vertical Drives in Water and Sewage Treatment," which is being distributed by Universal Gear Corp., of Indianapolis. It discusses mechanical mixing, tank design, clarifier mechanism drive, comminutor drive, and the adaptation of Universal Moto-Gear Drives (Heliocentric Type) to typical installations of each. Power requirements are set forth and experiences are cited. At the end is a listing of installations. Address Universal Gear Corp., 19th and Martindale, Indianapolis, Ind.

"Modern Steam Engines":—Is the most complete (48 page) catalog yet seen on steam engines. It comes from the Troy Engine and Machine Company and sets forth applications of steam engines, outstanding features of design and advantages of the several types of engines illustrated. It contains numerous tables, specifications and drawings of engines and important working parts. For a copy of this very complete brochure (Catalog 305) address Troy Engine and Machine Company, Troy, Pa.

LFC

Big Problems—an everyday routine at LYNCHBURG

This "Special" casting was a problem for any foundry. It demanded excellent foundry practice and methods as well as accurate machine work... Yet—with more than half a century of experience such "Special" jobs actually become everyday routine at "Lynchburg".... For quick estimates write, wire or phone "Lynchburg."

Bell and Spigot Pipe and Fittings. From 4" to 54"
Cast Iron Flanged Pipe. From 3" to 84"
Cast Iron Flanged Fittings and Flanges from 1" to 84"
de Lavaud Centrifugal Cast-Iron Pipe

Special Iron Castings for the Chemical Industry

LYNCHBURG FOUNDRY COMPANY
General Office · Lynchburg, Virginia
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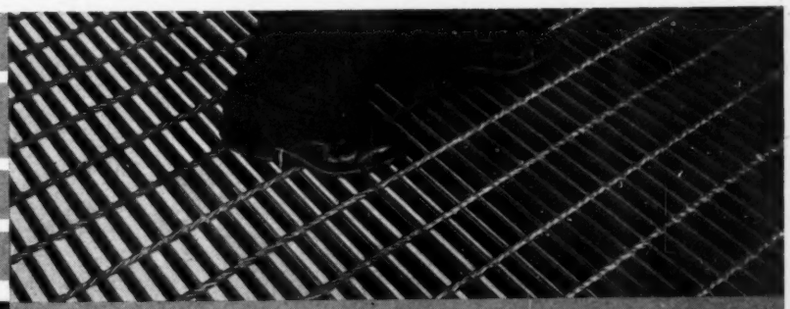
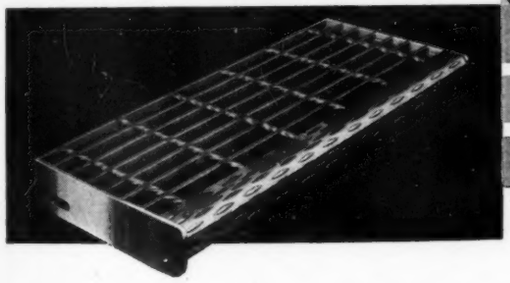
BLAW-KNOX
Electroforged
STEEL GRATING
AND TREADS





ONE PIECE • NON-SLIP
SELF-CLEANING
NO RATTLES • EASILY PAINTED

See and examine this one-piece, non-slip grating for yourself. We have prepared a sample, paper weight size, and will be glad to send it to you on request together with complete catalog. Just say—send Grating sample.

Blaw-Knox Steel Stair Treads are made from Electroforged steel grating using a nosing made from rolled diamond checkered plate which sharply defines the edge of each tread. Available in all standard sizes. Ask for Form 1498.

BLAW-KNOX COMPANY
2053 FARMERS BANK BUILDING · PITTSBURGH, PA.

That May

Convention and Data Edition of

WATER WORKS & SEWERAGE

is now on the desk of many hundreds of Water Works Superintendents. It serves as a ready reference manual that is of the utmost value in solving the varied problems that are constantly arising in the operation and maintenance of Water Works. Its usefulness is such that it most appropriately has been called the "OPERATORS' BIBLE."

"Aer-o-Mixing"

A *Distinctive* Process
In
Water and Sewage Treatment

"Jung Suction"
AERO-MIX
AERATOR - MIXER

IN WATER PLANTS

Raw Water Aeration
Quick Chemical Mixing
Coagulant Mixing
Contact Mixing
Recarbonation
Filtered Water Aeration

IN SEWAGE PLANTS

Activated Sludge Aeration
Trickling Filter Auxiliary
Mixing For Chemical Precipitation

INVOLVING

Diffusion
Compression
Retention
Expulsion
Surface Contact
Agglomeration

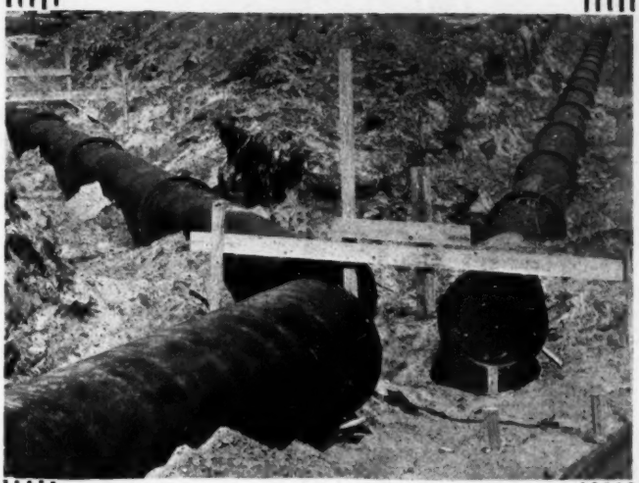
A type and capacity to fit every existing or contemplated plant.

Gravity—Rotary
Pneumatic—Pressure

Write for illustrated folder

VOGT MFG. CO., Inc. P. O. BOX 1122 LOUISVILLE - - KY.

"ACIPCO"

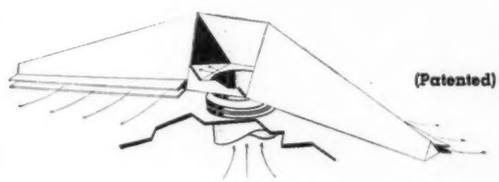


MONO-CAST Centrifugal Pipe being installed in new sewage disposal plant, Austin, Texas. Pipe in left foreground is 36" main sewer; pipe in left background is 30" main sewer running to plant; pipe leading from center to deep background is 30" by-pass line. "Acipco" furnishes a complete range of cast-iron pipe and fittings for modern sewage disposal plant construction. For literature address American Cast Iron Pipe Co., Birmingham, Ala.

SPRAY-DRYING CHAMBERS

Air Driven Floor Sweeper

In-drawn air divides equally to the sweeper's arms. Discharged from the arms against the floor of the Chamber, it rotates the sweeper; and simultaneously sweeps the dust into an outgoing air-stream.



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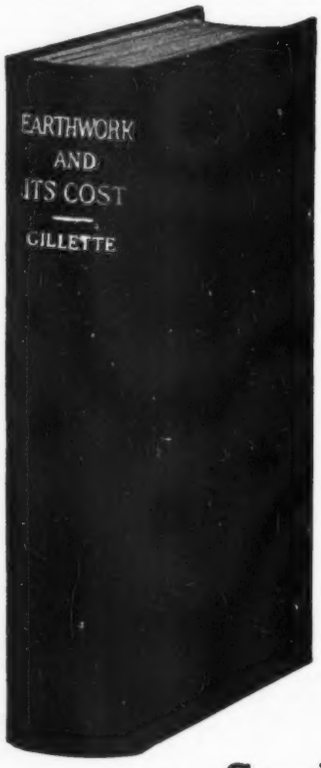

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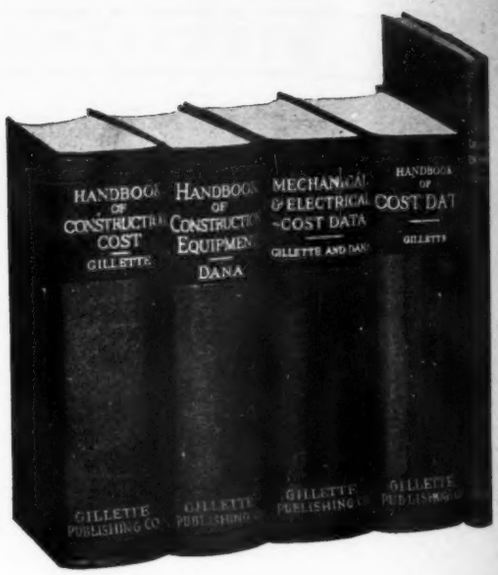

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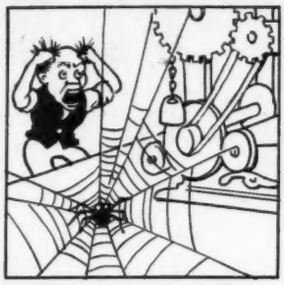

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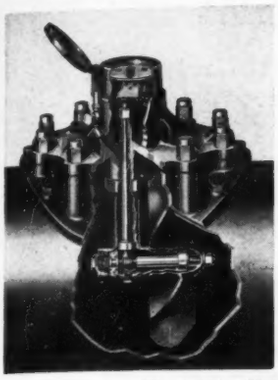

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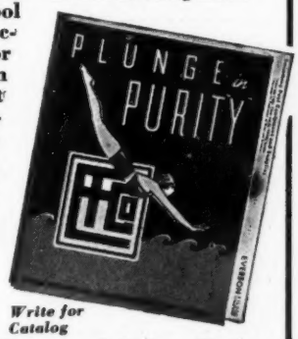

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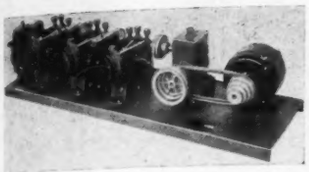

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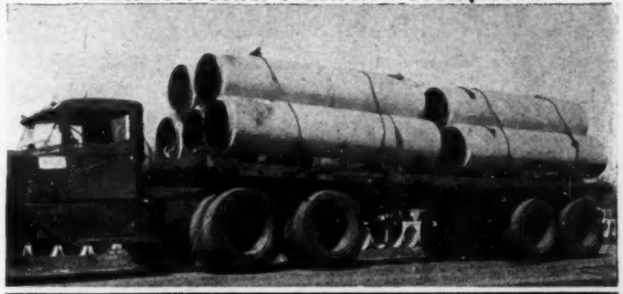

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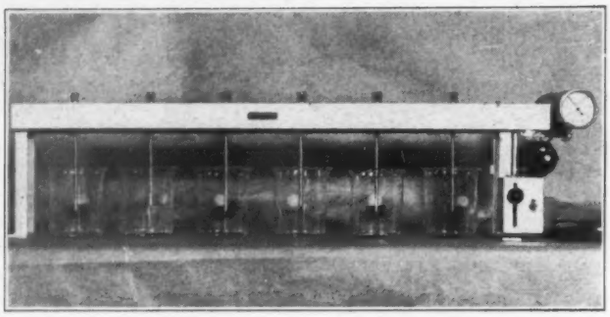

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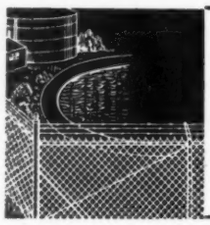

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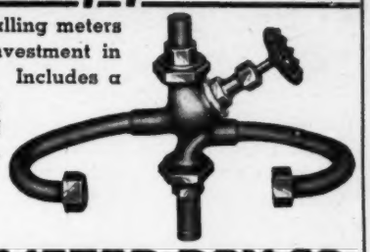

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A

Activated Alum Corp. ... 98
Alvord, Burdick & Howson ... 99
American Cast Iron Pipe Company ... 91
*American Centrifugal Corp ... 85
Arrowhead Iron Works ... 98
Atlas Mineral Products Co. of Pa., The ... 99

B

Biltmore Hotel ... 97
Black and Veatch ... 99
Blaw-Knox Company ... 89
Bowen Research Corporation ... 91
Builders Iron Foundry ... 8
Burns & McDonnell Engr. Co ... 99

C

*Carborundum Company, The ... 21
Cast Iron Pipe Research Asso., The ... 24
Chain Belt Company ... 22
Champion Corporation ... 88
Chester Engrs., The J. N ... 99
Chicago Pump Company ... 18
Chicago Rawhide Mfg. Co ... 99
Chicago Testing Laboratory, Inc ... 99
Clark Controller Co., The ... 83
Columbia Alkali Corp ... 4
Columbian Iron Works ... 97

D

*Dorr Company, Inc., The ... Third Cover
Dresser Mfg. Company, S. R ... 85

E

*Edson Corporation, The ... 98
Electro Bleaching Gas Co ... 19
Everson Mfg. Co ... 95

F

Ford Meter Box Co ... 99
Fuller & McClintock ... 99

G

Gillespie Co., T. A ... 5
Gillette Publishing Company ... 16-92-94
*Golden-Anderson Valve Spec. Co ... 87
*Gruendler Crusher & Pulv. Co ... 97

H

Hellige, Inc. ... 97
Hill, Jr., Nicholas S ... 99
Hills-McCanna Co. ... 11
Hudson Coal Co., The ... 95

I

*Industrial Chemical Sales Co., Inc ... 9
*International Filter Co ... 93

J

Johns-Manville ... 6-7

K

Knowles, Inc., Morris ... 99

L

La Motte Chemical Products Co ... 98
Layne & Bowler, Inc ... 93
Link Belt Co ... 12
Lock Joint Pipe Co ... 97
Ludlow Valve Mfg. Co., The ... 92
Lynchburg Foundry Company ... 89

M

Mathieson Alkali Works, Inc., The ... 10
McWane Cast Iron Pipe Co ... 83
Metcalf & Eddy ... 99
Mueller Co. ... 97

N

*National Water Main Cleaning Co ... 93

P

Pacific States Cast Iron Pipe Co ... 83
*Pennsylvania Salt Mfg. Co ... 3
*Permutit Company, The ... 86
*Phipps & Bird, Inc ... 98
Pirnie, Malcolm ... 99
*Pittsburgh-Des Moines Steel Co ... 13
Pittsburgh Equitable Meter Co ... Front Cover
Pittsburgh Steel Co ... 88
Portland Cement Association ... 14
Potter, Alexander ... 99
Powell, Shepard T ... 99
Proportioneers, Inc. ... 97

R

Roberts Filter Mfg. Co ... 99
Royer Foundry & Machine Co ... 15

S

Sika, Inc. ... 91
*Simplex Valve & Meter Co ... 17
Sonken-Galamba Corp. ... 98
South Bend Foundry Co ... 98
Sparling, R. W ... 95
Stewart Iron Works Co., Inc., The ... 98

T

*Taylor & Co., Inc., W. A ... 95

U

*United States Pipe & Foundry Co ... Second Cover

V

Victor Equipment Company ... 92
*Vogt Mfg. Co., Inc ... 91

W

*Wallace & Tiernan Co ... Back Cover
Whitman & Howard ... 99
Wilson Chemical Feeders, Inc ... 97
Wilson, P. S ... 99
*Wood Co., R. D ... 20

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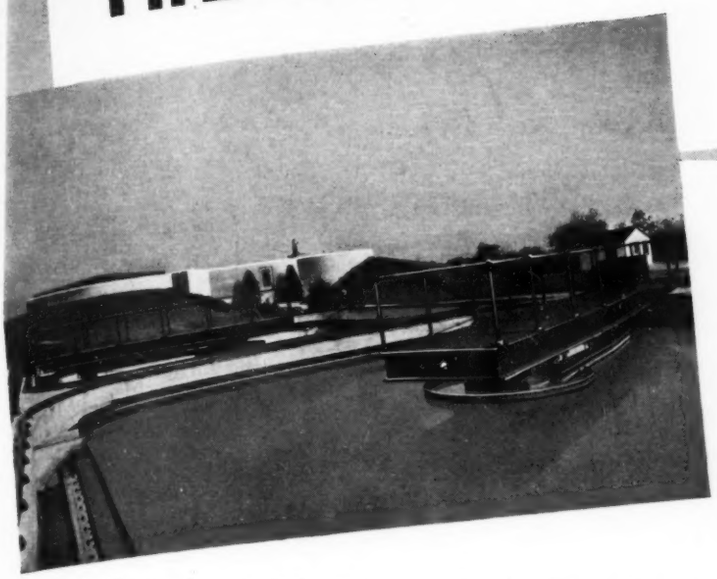

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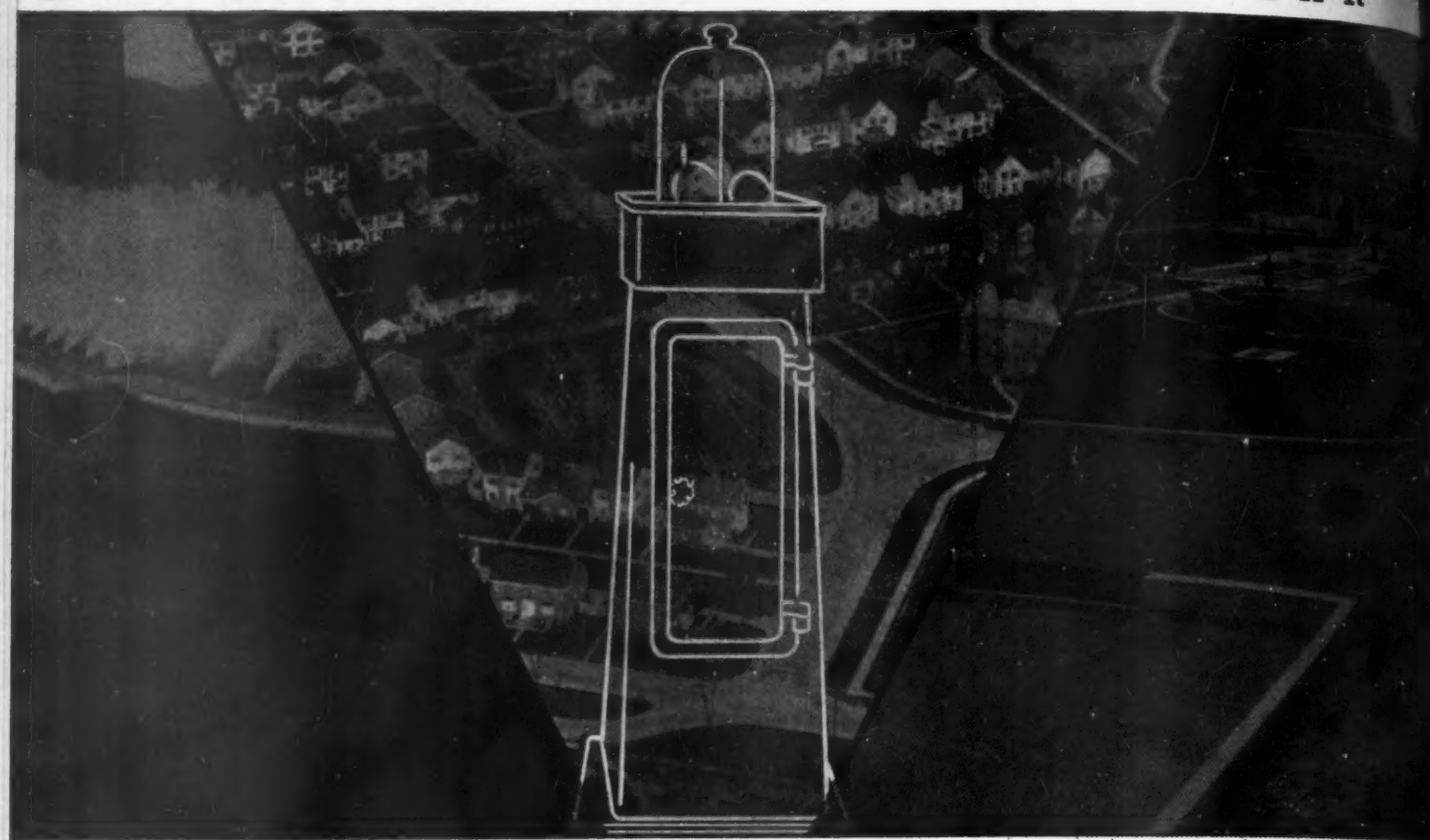

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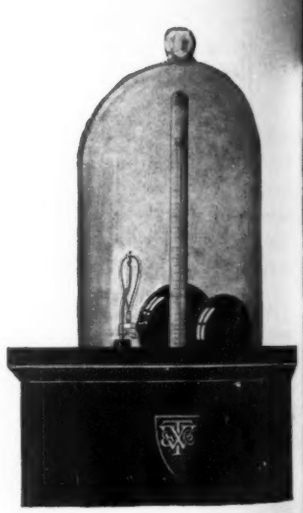

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